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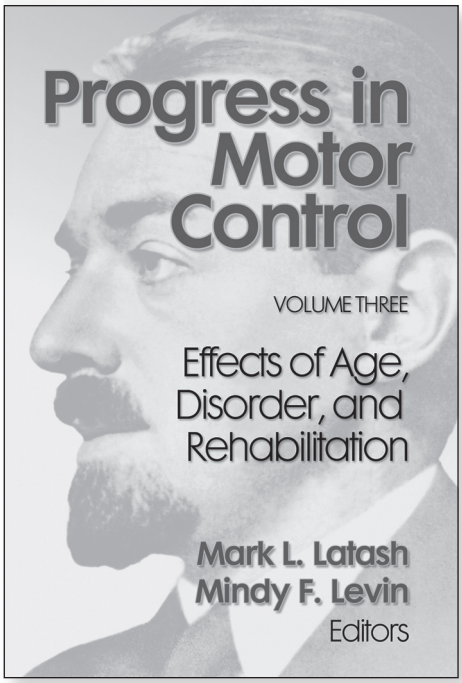
Applying theory to movement disorders and motor rehabilitation



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Mark L. Latash, PhD, and Mindy F. Levin, PhD, PT, Editors
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Progress in Motor Control, Volume Three, explores theoretical and experimental motor control studies, presenting cutting-edge research and experimental findings in motor control literature. In this reference, you'll find the viewpoints of many of the world's experts in motor control, and you'll see how to apply their latest insights to clinical problems.

Progress in Motor Control, Volume Three, continues the tradition of the great Nikolai Bernstein, one of the founders in the field of motor control. This book bridges the gap between theory and practice for professionals working in the area of impaired motor coordination, and it appeals to a broad audience by crossing into applied areas such as aging, development, and rehabilitation. This third volume highlights changes in motor control with age and neurological disorder, including effects on posture, balance control, motor learning, and rehabilitation after a stroke. It is a valuable resource for a wide range of professionals working in basic and applied areas of motor control.

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Abstracts of Oral Presentations

Computing with Neural Ensembles

Miguel Nicolelis
Neurobiology, Duke University Medical Center

In this talk, I will review a series of recent experiments demonstrating the possibility of using real-time computational models to investigate how ensembles of neurons encode motor information. These experiments have revealed that brain-machine interfaces can be used not only to study fundamental aspects of neural ensemble physiology, but they can also serve as an experimental paradigm aimed at testing the design of modern neuroprosthetic devices. I will also describe evidence indicating that continuous operation of a closed-loop brain-machine interface, which utilizes a robotic arm as its main actuator, can induce significant changes in the physiological properties of neurons located in multiple motor and sensory cortical areas. This raises the hypothesis of whether the properties of a robot arm, or any other tool, can be assimilated by neuronal representations as if they were simple extensions of the subject's own body.

Schizophrenia: Serial Order Processing Deficit?

James Houk
Dept of Physiology, Northwestern University

When a sequence of k spatial targets are observed and then maintained in working memory, normal subjects have no difficulty recalling k = 1-4 targets. However, schizophrenia patients make huge errors for k = 3 or 4 (Fraser et al., 2004). Based on the Beiser-Houk (1998) model of loops between basal ganglia and cerebral cortex, the deficit is likely to reside in the caudate nucleus of the neostriatum where spiny neurons compete with each other in a pattern classification operation. This hypothesis contrasts with the widespread belief that a core feature of schizophrenia is a deficit in working memory residing in the dorso-lateral prefrontal cortex (Lewis & Gonzalez-Burgos, 2006). In an imaging study of serial order recall in normal subjects, we observed a statistically significant BOLD decrease in the caudate nucleus for a contrast that was designed to focus on a decoding operation that performs serial order recall (Houk et al., 2007). Since BOLD is believed to mainly reflect synaptic activity (Logothetis, 2002), this was a puzzling result – an area of the brain known to participate in serial order recall was showing a decrease in BOLD. In an attempt to understand this puzzle, we used a specific model of serial order processing based on the general model introduced in Agents of the Mind (Houk, 2005). When the competition between spiny neurons in the caudate nucleus was modeled by presynaptic, as opposed to postsynaptic, inhibition, the

model performed better in the presence of noise while also explaining the decrease in BOLD. Presynaptic inhibition is not only computationally more powerful, it also decreases synaptic input in the network of competing spiny neurons. How does competition mediated by presynaptic inhibition relate to schizophrenia? The central paradox of schizophrenia (Crow, 2000) is that the genetic deficit survives in about 1% of the population in spite of a substantial fecundity disadvantage. I propose that a genetic mutation improving the coding of the GABAb receptor that mediates presynaptic inhibition occurred in primates and led to the evolution of language, intelligence and complex social relations. Improved pattern classification could explain the survival of the gene in the population, whereas unfavorable expression of this gene with a 1% incidence could explain the central paradox of schizophrenia (Houk, 2007).

Symposium I: New Approaches to Movement Rehabilitation

Functional Electrical Therapy (FET) of Walking for Neurorehabilitation in Hemiplegic Individuals

Dejan Popovic
Center for Sensory Motor Interaction, Aalborg University, Denmark

The randomized clinical study of neurorehabilitation of walking included acute hemiplegic individuals who could stand, but could walk only assisted by a therapist or a walker. Subjects participated in a 4-week program that comprised 30 min long daily walking sessions augmented with multichannel electrical stimulation that was timed to promote the stance (2 channels) and the swing (3 channels) of the paretic leg. The main outcome measures were the walking speed and symmetry index. Significant improvement in the walking speed and symmetry index, compared to the control group, was found at the end of therapy. Significant difference was also found when comparing the end of the therapy with the beginning in both groups. In the follow up study (6 months) the differences were decreased; yet, they were still statistically significant between the groups. The finding was that the patterned electrical stimulation must better fit into the preferred walking pattern of the hemiplegic individual. The intragroup differences must be considered and sensory driven control should be applied for the best result. The results indicate that intensive exercise augmented with patterned electrical stimulation contributes to the faster recovery of function. This suggestion is now being confirmed by fMRI and TMS studies. The case studies in chronic subjects indicate that the period of dose used in the study with acute hemiplegic should be increased for better outcome.

Intensive Motor Rehabilitation in Cerebrovascular Stroke

Ina M. Tarkka
Brain Research and Rehabilitation Center Neuron

Cerebrovascular stroke is the sixth highest burden of disease world-wide in terms of disability adjusted life years and it is the most important cause of severe disability in people living in their own homes. The ability to perform basic activities

of daily living is initially reduced in three out of four patients with stroke. Stroke is a rapidly developing syndrome of vascular origin, either ischemic or hemorrhagic, manifesting symptoms and signs of focal loss of cerebral function. Many of the patients with stroke may have difficulties in ambulation, unilateral upper limb movements and in cognitive functions. For example, cognitive deficits as well as neglect are often associated with left hemiparesis and aphasia with right hemiparesis. Current neurorehabilitation strategies for cerebrovascular stroke are based on the remarkably increased knowledge of mammalian brain plasticity and the reorganizational capacity of the cerebral networks involved in motor control. Applying new knowledge in current neurorehabilitation can effectively change the functional outcomes of the survivors of severe cerebrovascular stroke. The new, effective methods for gait rehabilitation utilize partial body weight support and electromechanical gait trainers in the process of relearning independent gait. Highly intensive gait training can be started as early as 3-5 days after the cerebral incident and results of such early therapy will be discussed. The task-oriented therapies for paralyzed upper limb include the constraint-induced movement therapy (CIMT), where two weeks of supervised challenging exercise is performed with the affected upper limb in order to relearn its use while the unaffected hand and wrist is kept in a lightweight cast. The experience of CIMT rehabilitation for 100 survivors of stroke is shared. In addition, results of two electrical stimulation techniques, cutaneous electrical stimulation and functional stimulation of the paralyzed hand, will be presented. Electrical and hemodynamic brain imaging methods are utilized to illustrate the changes in cerebral motor control related to effective rehabilitation methods in survivors of stroke.

Robot Mediated Movement Therapy: A Tool for Training and Evaluation

Hermano Igo Krebs
Dept of Mechanical Engineering, Massachusetts Institute of Engineering

Stroke is the leading cause of permanent impairment and disability. MIT-MANUS, a robotic device which interactively treats stroke survivors, has been delivering targeted training for the paretic shoulder and elbow. In randomized controlled trials involving over 300 persons with both acute and chronic impairments after stroke, persons treated with the robotic protocol have demonstrated significant reductions in impairment in the exercised limb. We have expanded the trials for other limb segments including the wrist, the hand, and the ankle. I will discuss past and on-going trials, including a set of clinical trials with over 100 stroke patients in which the robot had distinct behaviors (progressive strength training, sensorimotor training, and performance-based training). While the robot possesses the native ability to record kinematic and force data, an ongoing challenge is to extract meaningful data from these measurements. Using the set of trials described above (different forms of robot training), I will show that robot-based assessment affords a unique insight into the relative advantage and disadvantage of each of these forms of training and this insight might support the clinician in selecting different protocols based on patient specific deficit. I will then discuss whether stroke patients are able to generalize recovery on the same and distinct workspace, as well as across distinct joints, and whether this generalization occurs in joint- or world-space. These results have important practical consideration as it is common clinical practice to advocate

that training must be task-specific. I will conclude by exploring different definitions of synergies among the clinical and neuroscience communities and show results from 164 stroke patients, both inpatient and outpatient that might help in clarifying these distinct definitions and their impact on neuro-recovery.

Manipulation of Sensory Feedback Using Virtual Environments for Motor Learning And Rehabilitation

Mindy Levin
School of Physical and Occupational Therapy, McGill University, Canada

Sensory information is used by the central nervous system to initiate and guide movement production. For example, the initiation and maintenance of gait is presumably driven by the internal transformation of the optic flow pattern whereby the environment is perceived as being motionless despite the motion of the body. Sensory information also provides information about the movement in the form of concurrent or post-movement feedback during the learning of a new motor skill. Virtual reality, a computer-based, interactive multisensory simulation that occurs in real-time, provides the opportunity to manipulate the environment to facilitate movement and to provide an enriched learning experience. Current studies using enhanced sensory feedback via virtual reality environments will be presented. The presentation will focus on motor relearning of upper limb movements in stroke survivors and on enhancing movement initiation and locomotion by manipulating optic flow patterns.

Symposium II: Sensory Integration for Postural Control

Sensory Compensation for Human Vestibular Loss

Fay Horak
Depts. of Neurology, Physiology and Pharmacology and Biomedical Engineering, Oregon Health and Science University

The effects of vestibular loss on balance function are quite varied across different patients but the reasons for this variation are not well understood. A series of studies in our laboratory has related the effects of vestibular loss on body kinematics and center of mass stability during surface perturbations and gait to their ability to use touch, auditory or vibrotactile biofeedback for sensory substitution. We found that subjects with profound bilateral loss of vestibular function showed increased trunk and head sway, especially while standing on foam or on an inclined surface with eyes closed. Light touch of a finger reduced postural sway similar to use of vision with some patients compensating more than others. The ability to use audio-biofeedback to reduce postural sway in stance depended on each subject's relative dependence on surface or visual information for postural orientation. Specifically, audiobiofeedback reduced sway the most with eyes closed in subjects most dependent upon vision and reduced sway the most when standing on a foam surface in subjects most dependent upon somatosensory information from the surface. Another study of subjects with unilateral loss of vestibular function showed increased trunk

instability during lateral surface oscillations consistent with a group average of 50% dependence on vestibular inputs compared to 100% in control subjects. Ability to use vestibular information for postural control, however, varied widely among subjects with unilateral loss and this variation was correlated with their balance confidence and activities of daily living. Specifically, subjects who depended upon their remaining vestibular function, rather than on surface inputs, appeared to have been better compensated. Biofeedback using a vibrotactile vest signaling lateral trunk sway improved postural instability during tandem gait in unilateral vestibular loss subjects. In conclusion, patients with vestibular deficits vary in their ability to use redundant sensory inputs and sensory substitution to improve postural stability with important implications for rehabilitation.

Identification of Human Postural Control Mechanisms Using a Model-based Interpretation of Experimental Results

Robert Peterka
Dept of Physiology and Pharmacology, Oregon Health and Science University

This presentation will describe how we have characterized the dynamic behavior of the human postural control system, how relatively simple control-system models can be used to interpret experimental results and to gain insight into the mechanisms contributing to postural control, and how these models can be used to understand abnormal postural behavior. Our lab has extensive experience using wide-bandwidth, continuous pseudorandom rotational stimuli applied to the support surface upon which the test subject stands, or to the visual surround viewed by the subject. Using a frequency-domain, transfer-function analysis, we find that body sway evoked by any particular stimulus can be quite accurately represented by a linear control-system model. However, overall dynamic behavior is nonlinear in that relatively less body sway is evoked by larger amplitude stimuli. This decrease in response sensitivity with increasing stimulus amplitude can be explained by a sensory integration mechanism that increases the contribution of vestibular cues, and decreases the contribution of proprioceptive or visual cues with increasing stimulus amplitude. A negative-feedback model-based interpretation of this "sensory re-weighting" accounts for postural behavior over a frequency range of about 0.1 to 1 Hz. To account for lower frequency postural behavior, we postulate the contribution of a positive feedback mechanism that senses the control effort and then generates a corrective action. This "effort control" mechanism ultimately results in a reduction of the overall energy required for stance control. Finally, the contributions of stretch reflexes, muscle activation, and muscle mechanics are needed to account for higher frequency behavior. When all of these mechanisms are included in a postural control model, the model predicts responses to transient perturbations (rapid surface translations or rotations) that closely match experimental responses reported in the traditional literature. This close match suggests that the mechanisms involved in the continuous regulation of posture are also responsible for the "motor programs" generated in response to transient disturbances. Furthermore, insights into the causes of abnormal postural control can be gained by comparison of model predictions to experimental results. Examples will demonstrate how the model can be used to understand the limitations imposed by a bilateral loss of vestibular function and by failure of the sensory-reweighting mechanism.

Erroneous Postural Adjustments Following Bilateral Vestibular Loss

Jane Macpherson
Dept of Physiology and Pharmacology, Oregon Health and Science University

Absence of vestibular information results in instability and difficulties maintaining balance under certain conditions. The underlying cause of this postural deficit is not well understood, given that somatosensory and visual inputs are available to the posture control system. Our studies of postural responses in the standing cat following bilateral labyrinthectomy reveal that instability and falling are linked to active destabilization on the part of the animal. For example, multidirectional rotation of the animal's support surface during stance elicits the exact opposite postural response compared to that elicited prior to the lesion. The cats actively push themselves toward the downhill side causing marked instability and even falling. This may reflect a strategy of orienting to the support surface using proprioception rather than orienting to earth vertical which requires vestibular input. Similarly, during voluntary head turns to left or right, lesioned animals initiate movement with the appropriate postural pattern, but after about 50 ms they generate an active force which propels the body to the side of the turn and causes instability and falling. We surmise that in the absence of vestibular information, subjects misinterpret the motion of the body in space and attempt to correct for illusory falling, thereby actively throwing themselves off balance. The illusion of falling may arise from neck inputs signaling head-on-trunk motion in the absence of vestibular inputs regarding head-in-space motion.

Symposium III: Laterality, Hemispheric Dominance and Inter-Limb Motor Control

Hemispheric Specialization for Control of Movement Trajectory and Steady State Position

Robert Sainburg
Dept of Kinesiology, Pennsylvania State University

Handedness has long been thought to result from a dominant system which is simply better developed to perform virtually any aspect of motor behavior. However, our research has suggested that each hemisphere/limb system has become specialized for different aspects of motor control. The dominant arm performs best in coordinating intersegmental dynamics and in controlling trajectory parameters, such as speed, direction, and curvature, whereas the nondominant arm tends to achieve more accurate and consistent steady state positions at the end of reaching movements. Studies that have examined interlimb differences in response to perturbations and in adaptation to novel task conditions have supported the idea that dominant control relies more on feedforward mechanisms to specify trajectory features, whereas nondominant control relies more on feedback mechanisms to modulate impedance. These different control strategies have been confirmed by interlimb differences in performance on tasks that vary either initial or final limb states, and are consistent with the performance of everyday bilateral activities, such as slicing a loaf of bread with the dominant arm while holding the loaf with the nondominant

arm. We recently tested our model of lateralization in unilaterally lesioned stroke patients. We examined whether ipsilesional deficits following stroke might reflect loss of the functions for which the ipsilateral hemisphere has become specialized. Our findings strongly support this hypothesis, and suggest that the ipsilesional, "non-affected" limb should be addressed from a remedial perspective in rehabilitation. This is particularly important in hemiparetic patients, when this limb most often becomes the lead-manipulator for activities of daily living.

Interhemispheric Interactions During the Production of Unimanual Movements

Timothy Verstynen and Richard Ivry
Dept of Psychology, University of California, Berkeley

Neuroimaging studies indicate that both hemispheres are frequently activated during unimanual hand movements. This is especially true during left hand movements. We have used a variety of methods to examine the conditions modulating the degree of ipsilateral activation during unimanual actions. Using fMRI, ipsilateral activation was found to increase when the planning and control requirements become more complex; this effect was observed when both sequential and configural requirements for the movements were manipulated. The center of the ipsilateral activity is anterior and lateral to the hand area in primary motor cortex, suggesting a distinct subregion of premotor cortex that is recruited during ipsilateral movements. When executing complex actions, the excitability of the ipsilateral primary motor cortex is lowered as evidenced by increases in TMS-induced motor-evoked potentials elicited in the stationary hand. Indeed, this increase may even lead to the manifestation of overt mirror movements in neurologically healthy adults. We consider two functional hypotheses for this ipsilateral activation. First, it could reflect the recruitment of ipsilateral descending pathways, providing an additional source of control for complex movements. Alternatively, complex movements might reflect bilateral planning processes and the ipsilateral premotor activity may help reduce unwanted activity in the hemisphere ipsilateral to the selected hand. Our preliminary evidence from studies that combine TMS and fMRI are supportive of the latter hypothesis. The degree of coupling between the two motor cortices during unimanual movements increased following repetitive TMS over the ipsilateral premotor region. By inference, we assume that the premotor region helps to minimize correlated activity of the two hemispheres, thus promoting independent control of the two hands during particularly complex actions.

Hemispheric Dominance for Different Aspects of Movement

Kathleen Haaland
Dept of Psychiatry, University of New Mexico

Although the motor system is primarily crossed with each hemisphere controlling movement primarily on the contralateral side, more subtle ipsilateral control is also present. Importantly, different aspects of movement are controlled by each hemisphere, and our results, based on studying ipsilesional reaching in stroke patients with unilateral damage, show that damage to the left hemisphere produces deficits in the movement trajectory and damage to the right hemisphere produces deficits in

final position. These findings are consistent with hand preference effects in healthy right handers and with the conclusion that the left hemisphere is more important for feedforward dynamic control and the right hemisphere is more important for online control.

Symposium IV: Stability and Variability

Understanding the Structure of Stability: Theory of the Uncontrolled Manifold

Gregor Schöner
Ruhr-Universität-Bochum, Germany
Valere Martin and John P. Scholz
Dept of Physical Therapy, University of Delaware

The concept of the uncontrolled manifold captures how the degrees of freedom problem is solved by the central nervous system. A theoretical account based on dynamical systems thinking proposes four sources of the task-specific structure of variance that has been observed in many different motor systems and task settings: (a) the coupling structure among joint virtual trajectories, (b) back-coupling of real joint trajectories into the planning system, (c) propagation of joint configurations from trial to trial, and (d) the structuring of joint variability by the direction of movement in joint space. The account provides an estimate of the relative contributions of muscle and neural noise and leads to a new view of motor equivalence. Theoretical ideas will be illustrated in reference to a wide range of experimental data sets.

Reaching Goals and Representing Space: Different Implications for Stability and Variability of Behavior

Sandro Mussa-Ivaldi
Depts. of Physiology, Physical Medicine and Rehabilitation and Biomedical Engineering, Northwestern University

Recent theoretical (Scholz & Schoner, 1999; Todorov & Jordan, 2002) and experimental (Latash, Scholz, & Schoner, 2002) studies have suggested that in order to insure stable behavior of a controlled endpoint, the motor system may exploit the possibility to redirect the variability of movements over subspaces defined by redundant degrees of freedom that do not have an effect on the portion of the controlled endpoint. According to the framework of Todorov and Jordan, an optimal controller is only concerned with the final goal of a movement and the shape of trajectories follows as a side-effect. Here I will present experimental results and theoretical considerations that go in a different direction, suggesting that the stability of trajectories and their spatiotemporal shapes leads to a stable representation of motor space and of its metric properties. In particular, the ability of the motor system to form consistent and repeatable behaviors requires the formation and the explicit control of degrees of freedom that are not contributing to the motion of the controlled endpoint.

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Stability and Variability in Performance and Learning of a Rhythmic Task

Dagmar Sternad
Dept of Kinesiology, Pennsylvania State University

As in walking and running the skill of rhythmically bouncing a ball in the air is profoundly governed by mechanical dynamics, where intermittent collisions are intertwined with continuous smooth movements. In previous work a dynamic model of the task, the ball bouncing map, was developed that afforded stability analyses with predictions about performance consistent with dynamically stable behavior. A series of experiments showed that human subjects performed the task consistent with the model predictions and exploited dynamic stability, i.e., they used a strategy where small noise or perturbations are compensated for without explicitly correcting for the error. For our recent experiments we created a virtual set-up with a haptic interface that afforded further tests of model predictions. The first experiment investigated the response of actors to perturbations, which was compared with simulation results of the model's basin of attraction. Experimental data revealed a mixed control strategy showing that humans exploit dynamic stability but also actively adapt the racket movements to perceived perturbations. The second experiment investigated how the actor's strategy changed when the contact dynamics was manipulated to produce different levels of stability. The deterministic ball bouncing model was extended with a stochastic component that yielded finer-grained predictions for steady state performance for different levels of stability. Results showed that with decreasing stability active control becomes more pronounced. The third and forth experiments investigated how novices learned, adapted and transferred the skill. The analysis of dynamic stability was complemented by an analysis of variability which decomposed the dispersion in a set of data into three components: tolerance, covariation and noise (TCN). Variability analysis of the redundant task afforded quantification of the exploratory component next to compensatory strategy and reduction of stochastic noise during learning, adaptation, and transfer. The four studies highlighted that humans flexibly intertwine different control strategies, mixing passive stability with active adjustments to changing task demands.

Symposium V: Do Internal Models Exist in our Brain?

Yes, We Need Internal Models

Pietro Morasso
Dept of Communication Computer and System Sciences, University of Genova

Although a universally accepted definition of internal model does not exist, most people in the field are likely to agree that even if we take into account that "the (human) brain has a body" there are neural assemblies whose activities can be decoupled to a large extent from actual sensorimotor patterns, although they are intimately related to sensorimotor integration. This is not the case at the other end of the spectrum of philogenetic development where neural control of movement is strictly reactive. In this sense, the emergence of internal models is associated with the progressive shift from purely reactive paradigms to model-driven paradigms of motor control as well as motor learning and motor reasoning. This does not imply that reactive systems are rigid whereas model-driven systems are not. Neural plasticity is already at work in the early stages of philogenetic development and in fact it is the main mechanism of environment adaptation for any form of life. The main push to the development of internal models is computational and it occurs in parallel to the increasing number of degrees of freedom and the associated task complexity. (Consider the control of manipulation, as a consequence of the opponent thumb, the control of the vocal tract during phonation, the precise control of eye movements as a consequence of the eye-resolution human fovea, etc.) In fact, increasing the brain mass for managing a more complex body is directly paid in terms of operational speed because the basic technology (the biophysics of the neuron) remains the same. The main breakthrough induced by the emergence of internal models of the body-environment dynamics is the fact that the same internal models that can improve sensorimotor control can be used for carrying out purely "mental simulations" of actions, which are essential for sensorimotor reasoning: decomposing an action into a sequence of sub-actions, if the main task cannot be achieved in a direct way; tool using and/or tool making if the physical parameters of the body are not appropriate/sufficient, etc. I shall explore some implications of the concepts above in relation with the stabilization of the upright posture, the control of the upper limb in relation with trajectory formation, the haptic interaction between robot and patient in robot therapy, and the biomimetic sensorimotor reasoning of a cognitive robot.

No, We Don't Need Internal Models

Mark Latash
Dept of Kinesiology, Pennsylvania State University

In the current motor control literature, the term "internal model" is used in two meanings. I would address those as non-specific and specific. In the non-specific meaning, an internal model is a neural structure that allows the central nervous system (CNS) to predict changes in the body configuration, external forces, and events. In this meaning, "internal model" seems to be synonymous with the established term "neural representation." The presence of some kind of neural representations of the physical world, including one's own body, has been accepted for many years. In the specific meaning, internal model means a particular computational procedure performed by neural structures to compute physical variables (such as forces, torques, and displacements) based on the current task and both afferent and efferent signals generated within the body. Most studies using this approach accept as an axiom that to perform a movement the CNS has to make sure that

requisite muscle forces are generated. As a result, most publications on internal models accept explicitly or implicitly that the CNS pre-computes muscle forces and joint torques required to produce movements and then it generates signals to spinal structures adequate to bring about these pre-computed forces and torques. I am going to argue that the specific notion of internal models is incompatible with experimental findings and general theoretical views on the control of systems with position and velocity-dependent force generators (muscles). In the non-specific meaning, the term is empty and misleading implying something "more scientific" than the established term "neural representation" while being synonymous with it. I am going to claim that currently there is only one motor control theory that does not view humans as poorly designed robots with powerful computers in their skulls—the equilibrium-point hypothesis.

Symposium VI: Neuromuscular Adaptations in Response to Physical Activity

Exercise Training and Motor Unit Discharge Behavior

Gary Kamen
Dept of Kinesiology, University of Massachusetts

Changes in muscle characteristics are well-recognized following resistance exercise training. However, we now know that there are numerous neural and neuromuscular adaptations that may also occur in both young and older adults. As the ''final common pathway,'' the study of human motor unit discharge behavior allows us to document these adaptations. Motor unit firing rate is amenable to change in older individuals, and we know that brief periods of resistance training produce increases in motor unit firing rates, likely attributable to changes in central drive. Doublet firing may improve muscular force production by utilizing the features of the ''catch'' principle and we know that doublet firing increases with training and is lower in older adults. The anecdotal literature suggests that motor unit synchronization might improve with exercise training; however, actual studies involving motor unit discharge behavior produce equivocal results regarding motor unit synchronization. These and other motor unit behavioral features will be discussed in this presentation.

Exercise-Induced Plasticity of the Human Brain

Tibor Hortobagyi
Dept of Exercise and Sport Science, East Carolina University

Motor exercise produces adaptations in the involved muscles and constitutes a fundamental element in the preparation for athletic performance and movement therapy. While the biochemical and the genetic processes of these adaptations in the muscle are well characterized, we know little about the changes that occur in the central nervous system. The purpose of this presentation is to provide a state-of-the-art update on the current understanding of the adaptive processes that take place in the human brain in response to acute and chronic exercise interventions

in health and disease. The review will focus on the use of transcranial magnetic brain stimulation as it can be used to assess long-term potentiation and depression as mechanisms underlying adaptations to motor exercise in humans.

Fascicle-Tendon Interaction During Normal Locomotion

Paavo Komi
Dept of Biology of Physical Activity, University of Jyväskylä, Finland

The natural way of the agonist muscle function is stretch-shortening cycle (SSC), in which the preactivated muscle is stretched and subsequently shortened. The in-vivo force measurement systems, buckle transducer technique (Komi, 1992), and optic fiber technique (Komi et al., 1996; Finni et al., 2001) have revealed that a nonfatiguing SSC exercise demonstrates considerable performance enhancement with increased force at a given shortening velocity. Characteristic to this phenomenon is very low EMG activity in the concentric phase of the cycle, but very pronounced contribution of the short-latency stretch-reflex component. The stretch reflex contributes significantly to force generation during the transition (stretch-shortening) phase in SSC action such as hopping and running (e.g., Komi & Gollhofer, 1997). As is obvious the occurrence of the stretch reflex requires that the muscles (fascicles) are truly stretched during the braking phase of SSC. The common assumption has been that in SSC activities both the muscle fiber compartment and the tendon would change their lengths in phase. This assumption has now been challenged, because muscle fibers have been estimated to stay at a constant length (Belli & Bosco, 1992) or they can even shorten (Griffiths, 1991) while the whole muscle-tendon complex may be lengthening. Although the "normal" SSC behavior has been shown clearly for the fascicles of the monoarticular soleus muscle, the results for the gastrocnemius muscle are somewhat controversial (see Fukunaga et al., 2001 and Ishikawa et al., 2006). However, our own results with higher ultrasound "sampling" frequency (96 Hz) are very convincing to demonstrate a very short fascicle stretching in the gastrocnemius (GA) muscle right upon the first moments of the ground contact. Consequently in SSC exercise the gastrocnemius fascicles are also stretched, although very shortly, thus allowing the Ia afferent activation to become effective. The suggestions of irregularity in the fascicle behavior emphasize the possibility that it may not only be muscle specific, but also movement and intensity specific. In the final end it also questions the generalization of the instantaneous force-length and force-velocity curves (Komi, 2000; Finni et al., 2001) equally to both parts of the muscle-tendon complex and to all muscles and movements. These results clearly indicate the existence of the intensity and muscle specific interactions between fascicles and tendinous tissue during normal SSC type locomotion.

Symposium VII: Detection of Neuromuscular Performance

The Surface EMG as a Source of Information on Motor Control

Roberto Merletti
Dept of Electronics, Politecnico di Torino, Italy

Aleš Holobar
System Software Laboratory, University of Maribor, Slovenia

The surface electromyographic (SEMG) signal is the summation of contributions from the active motor units within the muscle and contains information about their features. Some of this information can be extracted in "global" form and in "single motor unit" form. Global information concerns force (with considerable limitations), "global" muscle fiber conduction velocity, myoelectric manifestations of muscle fatigue and muscle activation intervals. Single motor unit information requires decomposition of the SEMG into the constituent trains of motor unit action potentials (MUAP) and is achievable only for the most superficial motor units. The individual MUAP trains provide information about the geometry and anatomy of the corresponding motor units, their recruitment threshold, firing rate and myoelectric manifestations of fatigue. The latter information provides insight into the motor unit type. The limitations and the reliability of this information will be discussed.

Estimation of Joint Torque and Impedance by Means of Surface EMG

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The central nervous system dynamically controls individual muscle tensions to affect movement and to interact with the environment. While it is not currently possible to non-invasively monitor these individual muscles tensions, their net effect is to modulate both torque and mechanical impedance about joints. Historically, surface EMG has been used to estimate joint torque. But, joint impedance is equally as important to understand, particularly in regard to how the musculoskeletal system interacts with the physical environment about it. Thus, we have begun an effort to use surface EMG to simultaneously estimate joint torque and impedance about the elbow. We begin by simultaneously monitoring multiple-channel EMG from the elbow flexors and extensors. From these ''raw'' EMG signals, optimized flexion and extension EMG amplitude estimates are formed. Then, system identification techniques are used to optimally estimate torque, and separately impedance, from the EMG amplitude estimates. Currently, we can optimally estimate elbow joint torque during force-varying, constant-posture contractions; and we are pursuing estimation of elbow joint impedance during quasi-static, constant-posture contractions. This presentation will review our optimal EMG amplitude estimation techniques as well as our on-going EMG-torque and EMG-impedance modeling techniques. These methods provide tools for examining and understanding the motor control properties of the human body.

Strategies for the Neural Control of Arm Movements Revealed by the Spatio-temporal Organization of Muscle Patterns

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How the CNS manages to control a complex dynamic system as the arm is an open question. To gain insight into the strategies for the neural control of arm movements, we have characterized the spatiotemporal organization of the muscle patterns observed during reaching movements in a variety of conditions. We have recorded surface electromyographic activity simultaneously from up to 19 arm and shoulder muscles and, using an optimization algorithm, we have decomposed the muscle patterns as the combination of multi-muscle time-varying components. Each component, a time-varying muscle synergy, represents the coordinated activation of a group of muscles with specific time-varying profiles. To construct a muscle pattern, different components are shifted in time, scaled in amplitude and summed together muscle by muscle. We have found that the combinations of just a few components (4-5) explain a large fraction of the variation in the muscle patterns for reaching in different directions, with different loads and forearm postures, in either point-to-point, reversal, or via-point movements. We have also found that the amplitude scaling coefficients are tuned to the direction of hand movement according to a cosine functions. These results suggest that the CNS simplifies the control problem by using a small set of rather complex motor commands together with a simple combination mechanism.

Symposium VIII: Optimality Principles in Motor Control

Stochastic Optimal Control and Bayesian Inference: An Emerging Theoretical Framework for Sensorimotor Integration

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A growing body of evidence supports the view that both sensory and motor processing are optimal in a probabilistic sense. Optimal performance in an uncertain environment requires Bayesian inference on the sensory side combined with stochastic optimal control on the motor side. In this talk I will briefly summarize key pieces of evidence supporting this theory, and then focus on clarifying its relationship to other theoretical ideas in the field: equilibrium-point and impedance control, internal models and adaptation, dynamical systems and pattern generators, uncontrolled manifolds, coordinate frames, and motor synergies. I will also discuss new applications of the theory: predicting neural population codes, understanding exploratory movements, and inferring behavioral goals from movement data.

Is Optimal Useful?

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For most of the 20th century, the guiding principles of motor neurophysiology were essentially clockworks: reflexes, servocontrol, canonical coordinate frames, etc. Sensory neurophysiologists quickly embraced perceptrons and other neural network concepts in which the driving force was actual sensory experience rather than a priori mechanisms. Only recently has motor neurophysiology tried to account for phenomena that have always been self-evident to athletic trainers and rehabilitation

therapists—namely, that every element from muscles to cortex is endowed with the ability to alter its properties and functionality according to performance experience. It is not much of a leap from Darwinian evolution to hypothesize that the trophisms responsible for this adaptive plasticity should give rise to optimized performance. Optimal control generally consists of a demonstration that lifelike performance can be mimicked by adaptive controllers trained to mimic lifelike performance, which may be just as circular as it sounds. Furthermore, these adaptive controllers are usually designed to mimic one small part of an extensive and hierarchical sensorimotor nervous system; the many other parts are ignored and/or assumed to be static. We know from clinical neurology that these different parts appear to be responsible for very different aspects of performance, but we have no idea how or why that happens without invoking a priori clockwork. This theoretical shortcoming has real implications when we attempt to intervene therapeutically in damaged sensorimotor nervous systems. Prosthetic components must interface with and adapt gracefully to the residual biological components and their inherent but presumably delimited forms of plasticity. A theory of computation that cannot distinguish among somatosensory and motor cortical areas, basal ganglia, cerebellum and spinal cord has limited utility to explain the distinct functional deficits that arise in these structures or to anticipate how they will respond to any novel treatment.

Interpreting Primary Motor Cortex Function Based on Optimal Feedback Control

Stephen Scott
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Primary motor cortex (MI) is a key component of the volitional motor system providing the largest contribution to the corticospinal tract and receiving input from many cortical and subcortical structures. The most common approach for interpreting MI function has been based on the notion of sensorimotor transformations, focusing attention on experiments that identify which coordinate frame best describes neural activity in MI. However, myriad coordinate frames or neural representations have been observed illustrating correlations with spatial goals, hand motion, joint motion, muscular torque, muscular power and EMG activity. How all these "representations" contribute or create coordinated motor behavior remains unclear. The focus of my talk will be to provide an alternate approach for interpreting MI function based on optimal feedback control. This approach re-emphasizes the importance of sensory feedback to MI function and the adaptive nature of long-latency reflexes that predominantly involve a transcortical pathway through MI. I will describe experiments that examine the highly adaptive nature of long-latency reflexes in humans either to maintain online control or to rapidly switch behavioral goals. I hope to present preliminary observations illustrating corresponding rapid context-dependent changes in the response of MI neurons of non-human primates for these same tasks.

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Abstracts of Poster Presentations

Brain and Neurophysiology

Facilitation of Flexion Reflexes Is Associated With Performing But Not Learning a Precision Locomotor Task

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The aim of this study was to investigate the interaction between learning and performing a precision locomotor task and flexion reflex (FR) modulation. Healthy subjects had to minimize foot clearance when repeatedly stepping on a treadmill over a randomly approaching obstacle. The subjects walked with reduced vision and were informed about the approaching obstacle and task performance by acoustic warning and feedback signals, respectively. FR was randomly elicited by tibial nerve stimulation (with non-nociceptive and nociceptive stimulus intensity) at mid-stance in both normal stepping and before stepping over the obstacle. Foot clearance and electromyographic activity (EMG) of several leg muscles were analyzed during obstacle stepping. The FR amplitude was enhanced prior to all obstacle steps, independent of stimulus intensity. This enhancement depended on the subject's awareness of the approaching obstacle. Improved performance was reflected in a decreased foot clearance and EMG amplitude but did not correlate with the course of FR amplitude. It is concluded that obstacle stepping is associated with a facilitation of FR pathways, probably by supraspinal drive. This facilitation might provide assistance for a safe obstacle stepping, e.g., to compensate quickly if a resistance becomes encountered.

Predicting a Hand Action After Parietal or Premotor Cortex Lesion

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Introduction: In accordance with previous data (Nat Neurosci. 7(12):1299, 2004), the knowledge of an upcoming movement is sufficient to excite one's own motor system, enabling an anticipatory reaction. This ability may be grounded by the so-called "mirror system." Mirror neurons, described in the monkey's F5 pre-motor

area and in the parietal cortex, are active during movement execution but also when the animal watches passively the same movement performed by another animal or the experimenter (Neurophysiol. 73, 2608-11, 1995). Recent neuroimaging studies have argued that in humans a similar neural execution/observation mechanism may also exist. The role of human parietal and pre-motor areas in the action anticipation context has however not been specified yet. *Methods*: We recorded the readiness potential (RP) while subjects watched movies of an actor grasping a green object (Mov_obs condition). When the object was red the actor's hand remained stationary (NO-MovObs condition). Thus, subjects could predict from the color of the object if the movement was going to occur or not. In a control task the subject performed a real movement by pressing a button after a cue (Action condition). Six patients with inferior parietal cortex lesion (BA 39/40), four patients with pre-motor damage (BA 44/45 and 46) and eight age-paired control subjects participated in the experiment. EEG (65-channel Geodesic Sensor Net) and EMG signals were recorded. RP slope was calculated using a linear regression for each condition and for each subject. ANOVA and Fisher LSD post hoc test were employed. *Results*: In accordance with previous data (Kilner et al., Nat Neurosci., 2004), control subjects showed a RP negativity prior to executing the movement (Action condition) and when expecting to see the movement (Mov_obs condition). No negativity signal was observed in NO-MovObs condition ($p = 0.014$). Pre-motor patients behaved like normal controls by showing a RP negativity both in action condition and during Mov_obs condition ($p = 0.250$). Moreover, RP negativity in Mov_obs condition differed from the NO-MovObs ($p = 0.006$). In contrast parietal patients did not show any RP in the MOV_obs condition ($p = 0.000$), (Mov_obs vs NO-MovObs condition, $p = 0.105$) although showing a RP when really performing the movement (Action condition). *Conclusion*: The absence of a RP in the Mov_obs condition for parietal patients suggests that, contrarily to control subjects and pre-motor patients, they are unable to predict impending movements. These data suggest that parietal cortex plays a key role for movement prediction even in the context of movement observation.

EEG Alpha Power Habituation Along Trials During Repetitive Motor Imagery of Complex Task

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Motor imagery (MI) is considered a mental state associated with simulation of movements, without any efferent output. Furthermore, distinct MI modalities activate different brain areas, changing the electroencephalogram (EEG) and hence its power spectrum, especially in the alpha band. The response to MI can also be measured up as an "endogenous" event-related potential (ERP). It is already established that during a complex task, the ERP can habituate along time, but it is still questioned what occurs in the alpha band. This work aims at investigating the alpha band power, focusing in the vicinity of the alpha peak (BPA), during repetitive MI of the spike volleyball movement. Thirty right-handed male subjects (age 18-40 years) were assigned to either an "athlete" group (GA), composed of experienced volleyball players, or a "non-athlete" (GNA) group, both with 15

volunteers. The Revised Movement Imagery Questionnaire (MIQ-R), involving kinesthetic and visual modalities of MI, was used to assess each subject's ability to imagine movements. After a video presentation of this complex volleyball task, multi-channel EEG in occipital (O1 and O2) and parietal regions (P3 and P4) with earlobes reference was acquired at rest condition (RST) and during kinesthetic (MIK) and visual (MIV) MI modalities (each one repeated 30 times). In order to test the vividness during MIK and MIV, the respective sub-scales of MIQ-R were carried out. After EEG artifact rejection, 24 trials, each with 5 s duration, were selected and the record subdivided sequentially into three segments (S1, S2 and S3), containing eight trials. For each segment the power spectral density was estimated using the Bartlett periodogram method and then the BPA was determined. The Student *t* test (alpha = 0.05) indicated no difference in MIQ-R mean scores between groups or MI modalities, but athletes imagine themselves more clearly than non-athletes during MIK and MIV. The paired Wilcoxon test (alpha = 0.05) reveals no significant differences in BPA between S2 and S3 for any EEG derivation and MI modalities. On the other hand, significant differences in BPA comparing S1 to S2 and S1 to S3 were found in MIK but not in MIV. These occur in both hemispheres for GA and in the right hemisphere for GNA. These findings suggest that the repetitive kinesthetic MI implies in habituation of the power in the alpha peak vicinity, mainly at the beginning of the task. Moreover, it does depend on the individual knowledge of the real motor task execution.

Motor Evoked Potential and Silent Period Change Under Magnetic Stimulation During Isometric Muscle Contraction in Humans

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Twelve healthy males, age 20 to 23 years old, took part in the research. The motor evoked potentials (MEP) were recorded using the electroneuromyograph Neuro-MEP-8 (Neurosoft Co., Russia). The surface electrodes were located on m. gastrocnemius mediale (GM). The persons under test performed an isometric muscle contraction (IMC) by plantar flexion of the foot (75% of the maximum voluntary contraction (MVC)) during 30s in the sitting position, in the dynamographic system Biodex (Biodex Medical Systems, USA). The magnetic stimulus was applied to the motor cortex, the spinal cord segment S1 and n. tibialis (Tib) using the magnetic stimulator Neuro-MS (Neurosoft Co., Russia) at rest, at the 1st, 15th, and 30th seconds of the IMC. The maximum MEP amplitude, cortical (CSP) and peripheral (PSP) silent periods. It was determined that the maximum amplitude of the GM MEP under transcranial magnetic stimulation (TMS) of the motor cortex, which was 0.7 mV at rest, increased reliably to 2.8 mV (by 400%, $p < 0.01$) at the 1st second, to 4.7 mV (by 671%, $p < 0.01$) at the 15th second, and to 3.9 mV (by 557%, $p < 0.01$) at the 30th second of the IMC. Under magnetic stimulation of the spinal cord, the maximum amplitude of the GM MEP increased from the background value of 0.7 mV to 2.6 mV (by 371%, $p < 0.05$) at the 1st second, to 2.2 mV (by 314%, $p < 0.05$) at the 15th second, and to 4.4 mV (by 628%, $p < 0.01$) at the 30th second of the IMC. Under magnetic stimulation of Tib, the GM MEP decreased from 6.4 mV to 3.9 mV at the 1st second (by 60.9%, $p < 0.05$), to 2.7 mV (by 42.2%, $p < 0.05$) at the 15th second of the IMC, and did not change any further. The GM CSP,

which was 47 ms at the 1st second, decreased reliably to 33 ms ($p < 0.05$) at the 15th second, and increased to 59 ms ($p < 0.05$) at the 30th second of the IMC under TMS of the motor cortex. The GM PSP was 26 ms at the 1st second, and increased to 28 ms at the 30th second under magnetic stimulation of the spinal cord. The GM PSP was 5 ms at the 1st second, increased to 12 ms at the 15th second, and decreased again to 7 ms ($p < 0.05$) at the 30th second under magnetic stimulation of Tib. The GM PSP did not change reliably during the IMC, and was 31 to 33 ms under electrical stimulation of Tib. Thus, activation of the cerebral cortex inhibition systems occurs in the second half of the IMC.

Response of the Deep Paraspinal Muscles to Cortical But Not Transmastoid Stimulation Is Increased at a Single Lumbar Level Following Interverebral Disc Lesion

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Morphological and behavioral changes in paraspinal muscles are common in back pain and injury. Recent data indicate that the size of the deep paraspinal muscle, multifidus, is reduced at the injured segment within 3 days following an experimental injury to the intervertebral disc (IVD) in pigs. The mechanism is unclear but may be due to changes in neural drive. We investigated changes in the excitability of corticomotor pathway by evaluation of the response of the paraspinal muscles to descending volleys excited by electrical stimulation of the motor cortex and the corticospinal tract at the cervicomedullary junction. Electrical stimulation of the cortex activates the cortical cells directly and indirectly and is therefore affected by cortical excitability. In contrast a transmastoid stimulus activates the corticospinal axons directly. As corticospinal synapses lack pre-synaptic inhibition the response to transmastoid stimulation is likely to reflect changes in the motoneurons. By comparison of changes in the response to these two stimuli we aimed to identify the extent and site (cortex or motoneuron) of changes in corticomotor excitability in response to IVD injury. Motor evoked potentials (MEP) were elicited by electrical cortical stimulation in 12 Swedish landrace pigs (weight: 30 kg) before injury, after an abdominal incision, after injury to the L3-4 IVD, and 15 min after the IVD lesion. In two pigs the response to cervicomedullary stimulation (CMEP) was investigated. In a further five pigs the same procedure was followed but with no IVD lesion. Pigs were maintained under controlled anesthetic conditions throughout the experiment. MEPs were recorded in deep and superficial regions of multifidus at L3-5 on the lesioned side and at L4 contralaterally with intramuscular electrodes. Although MEP amplitude was increased for several muscles after incision, at 15 min after IVD lesion only the MEP amplitude of the deep multifidus at L4 on the lesioned side was increased (36(15)%) ($p < 0.05$). There was no change in MEP amplitude contralaterally or at the level above or below the lesion. There was no change in the amplitude of the CMEP after injury. These data indicate that IVD lesion induces a localized increase in excitability of the motor cortex, but not the motoneuron, in the deep paraspinal muscles that cross the injured segment. These

data not only suggest that cortical excitability is changed by pain, but that this can be specific to the input to localized region of muscle fascicles, confirming the exquisite organization of the motor cortex.

M-Wave Analysis During Fatigue of the Anterior Tibial Musculature at Room Temperature and Infrared Exposure

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In the present study, we have analyzed the behavior of the maximum M-wave into the anterior tibial muscle and flex-foot isometric torque during maximum voluntary contraction (MVC) over 60 s, at room temperature or during infra-red exposure. Experimental procedures were performed on four normal individuals showing no neurological or skeletal muscle malformations (average of 25, 25 years-old). For this, we have used a pedal containing a power transduction to register the torque generated during MVC, in such a way that the maximum torque data were transmitted to a computer screen by the LabView program. To capture muscular electromyography (EMG) signals, we utilized two surface electrodes. To stimulate maximum M-wave, we additionally used a bipolar stimulation electrode over the fibular head. The temperature was registered by a surface thermometer. During MVC period (60 s period), individuals accompanied generated torque in a graphic view on the computer screen, since they were asked to keep maximum torque. As a result, we obtained a statistically significant increase of maximum M-wave amplitude after the 60 s period, both at room temperature and infrared exposure (lower levels at this last condition). Regarding the maximum torque, we observed a significant decrease of this value after MVC at room temperature. We conclude that alterations of M-wave amplitude and torque intensity frequently occur after a 60 s MVC period.

Detection of "Motion" in a Hypnotically Stiffened Arm

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Classic hypnotic effects often involve alterations in the perception of control of motor movements, for example, suggesting to hypnotized subjects that their arm is becoming very stiff and then challenging them to try to bend it. The classic hypnotic response is that when subjects try to bend their arm, they find they cannot. In this study, we specifically addressed the problem of characterizing the underlying nature of "stationarity" or the "stiffness" or "immobility" of the arm during the challenge. Given that the neural mechanisms underlying these processes are presently under intensive study, we examined whether techniques utilizing the precepts of directional statistics would be sensitive to stationarity or lack thereof. Subjects were pre-screened for their hypnotic susceptibility using standardized scales (the Waterloo Stanford Scale of Hypnotic Susceptibility, Form C) and graded as either Low- or High-Hypnotizable. In this study we only report on the High-hypnotizable subjects (n = 18). A magnetically based motion tracking system with 4 sensors was used to record the orientation (as a 3 × 3 matrix, R = R'R = +1) and position (vector of length 3) of the upper body (Rb), upper arm (Ru), lower arm (Rl) and

hand. The relative orientation of the upper body to the upper arm, the shoulder, and the lower arm with respect to the upper arm, the elbow, were of interest (Rs = RbTRu; Re = RuT Rl). Assuming that most of the shoulder movement was flexion/extension with a smaller component being in the coronal plane and that the elbow's motion is constrained to be only flexion and extension in this task, Rs and Re were converted to axis-angle form. Since each condition for each volunteer was of a different duration, the vectors of time-varying shoulder and elbow angles (θt) were interpolated using cubic splines to be all of constant length ($1 \leq t \leq 1000$). The data for each volunteer and condition (θvct) were then centered by removing the appropriate mean ($\theta vct - 1/1000 \Sigma \theta vct$), which provides a measure of the shoulder and elbow angles independent of volunteer's pose. This method of processing joint motion in space was sensitive to a resolution of less than 0.5 degrees. Although the results showed varying motor strategies when hypnotized subjects were challenged to bend a "stiffened" arm, overall there were statistically significant differences between the challenge portion of the task and the time leading up to the challenge. Comparison of shoulder and elbow behavior, just prior to the challenge vs. during the challenge, revealed a significant difference ($p \leq 0.05$). Furthermore the shoulder moved more than the elbow, possibly to constrain the elbow from moving. Because these differences were less than a degree, it is doubtful that they would be discernible to the naked eye.

Relationship Between Median Nerve Somatosensory Evoked Potential and Neurological Deficit In Quadriplegics—A Pilot Study

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Neurophysiological assessment of median nerve somatosensory evoked potential (SEP) is largely used in the functional evaluation of central and peripheral nervous systems. Quadriplegics have deficits in the upper and lower limb functions. Studies have reported median nerve SEP recordings of quadriplegics and the data obtained show different responses depending on the level and the type of lesion. However, there are no studies that related the lesion level and SEP data, therefore, the aim of this work was to evaluate the relationship between the level of spinal cord injury and the median nerve SEP recordings. This relationship is useful in assisting upper limb rehabilitation, because cortical recordings can mean a better probability of satisfactory treatment results. Seven quadriplegics (four with C7 and three C5), age 27-40 years old, with at least 18 months of lesion, all ASIA A, were analyzed. Neurological examination was performed according to the ASIA protocol. Electrophysiological evaluation was done through evoked potential equipment, with an electric impulse of 0.2 msec duration applied at 5 Hz and 10 kΩ of impedance. Three sets of 1,000 responses were acquired. The stimulus

intensity was adjusted to produce a clear muscle contraction or motor threshold level. The recording electrodes were located on the median nerve pathway: Erb's point, cervical intumescences and the cortical representation of the hand (based on the international 10/20 system). The study was approved by the local ethical committee. The SEP recordings were evaluated according to the presence or absence the N20 latency (cortical latency) and if they were normal or delayed. The N20 latency was observed in all patients C7 and data were similar to normal subjects (mean of latencies in the four patients was 19.84 ms). In the patients with lesion level C5, Erb's point recordings were present but recordings in the cortex were not observed. No neurological recording was detected in the cervical intumescences, probably due to scars or orthopedic implant (metal plate) in the lesion level. The median nerve is originated from roots C5-C7 and, because of this, cervical lesions can cause functional deficits in the upper limbs depending on the level of lesion. Preliminary studies have shown that in higher cervical lesions it was not possible to register SEPs in the cortex when compared to lower cervical lesions. This study suggests that the median nerve electrophysiological examination can have a relevant role in the evaluation of quadriplegic rehabilitation prognostic.

Relation Between Gait Speed, Muscle Strength, and Mioeletric Activity in Individuals with Multiple Sclerosis

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Introduction: Multiple sclerosis (MS) is a progressive degenerative neurological disorder of the myelin, which compromises the central nervous system, affecting motor control especially on gait ability. *Objective*: To establish the correlation between muscle recruitment and gait speed assess in MS patients compared with a control group. *Methods*: For the experimental group 7 individuals with MS were selected, and the control group had 7 healthy individuals. A 10 m platform was used to measure gait speed, besides the EMG recruitment of tibiallis anterior muscle was measured during the gait and in voluntary maximum isometric contraction. The muscle function was assessed based on Medical Research Council (MRC). *Results*: It was possible to see that muscle function in the control group compared with the experimental groups was better ($p = 0.016$). Comparing the muscular recruitment during the gait μV ($p < 0.001$), it showed a significant result, with the MS patients having a higher level of recruitment. Comparing gait speed in auto-selected way and fast, the experimental group performed with lower values in both situations ($p = 0.017$ and 0.009, respectively). *Conclusion*: There was an important reduction in the gait speed in patients with MS compared to a control group besides a bigger recruitment of the tibial anterior muscle in the experimental group. Based on the results it has been suggested to analyze other parameters such as muscle tonus, range of motion and the spatial and temporal action of lower limb muscles, as well as other gait synergetic muscles.

Relationship Between Gait Parameters and Balance In Individuals With Multiple Sclerosis

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Camila Torriani

Multiple sclerosis (MS) is a progressive neurological disorder, which degenerates the myelin, which is characterized as a demyelization of the central nervous system (CNS). It is the most common neurological disorder among young adults. The most common consequences can be seen in their gait pattern, balance and fatigue. Eighty-five percent of the patients present problems in gait. The combination of all these problems leads to a decrease in their mobility and their quality of life. *Purpose*: To establish a correlation between the gait parameters and balance among MS patients. *Methods*: Eight MS patients were selected for the experimental group and eight healthy people for the control group. To assess balance, the Berg Balance Scale (BBS) and the Functional Reach (FR) were used. After these procedures, three measurements of their gait were collected first at a comfortable (auto-selected) speed and then at a high speed for ten previously set meters. The subjects were wearing a pedometer to measure the speed of their walk, the steps length and cadence. For statistical analysis, Anova and Pearson´s correlation were used. *Results*: In the experimental group it could be observed that there was a decrease in the walk speed both when they were walking at a comfortable speed and at a high speed. It was also observed that both the static and the dynamic balance was altered leading to the conclusion that there was a correlation between the parameters of their walk and their balance performance. *Conclusion*: The alterations in the balance for patients with MS have a negative effect on the gait parameters both when they were walking at a comfortable speed and at a high speed. In order to complement the data it was suggested that the fatigue parameters, muscle strength and myoeletric activity which are gait synergetic muscles should be added. After all, muscle weakness and fatigue are the most important distressing and acute symptoms in patients with MS.

Information Theoretic Analysis of Bursting Neurons from the Stomatogastric Ganglion of Crustaceans

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The nervous system of the crab *Callinectes sapidus* was studied by using Information Theory. The lateral pyloric (LP) and pyloric dilator (PD), two reciprocally inhibitory bursting motor neurons from the stomatogastric ganglion, present characteristic interspike interval (ISI) patterns strongly dependent on the network connectivity (Szucs et. al, J. Neurophysiol. 89, 2003). The amount of information exchanged between these neurons was inferred by calculating the Average Mutual Information (AMI) of the ISI sequences of pairs of bursts (one neuron is set as stimulus and the other as response). The AMI estimates how much the response variability is used to code the stimulus variability. The first spike of one neuron's

burst was set as phase reference for the ISI patterns of the pair. After analyzing all pairs of bursts the AMI was computed from the joint probabilities of all patterns. Here we show that the AMI is non-homogeneous along the burst—some regions of the burst are more influential in information transfer than others. Moreover, if the phase information is discarded (by using independent phase references for stimuli and response) the AMI is significantly reduced, meaning that part of the information present in a burst is used to code the bursting phase of the other neuron. This suggests that a single motor neuron is able to express information of all neurons of the circuit and this information could be, in principle, recovered and used by higher neural centers. (Financial support from the Brazilian agencies FAPESP and CNPq is thankfully acknowledged.)

Age-Related Differences in Motor Readiness Potentials and Kinematics During Goal-Directed Reaching in Children and Adults

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Introduction: Age-related improvements in the kinematics of goal-directed reaching may be related to the continued brain development underlying sensorimotor integration, motor planning, and motor control. However, little is known about the relationship between the emergence of coordinated, multi-joint, visuomotor behaviors and the developmental changes in the functional areas of the brain. The purpose of this study was to characterize age-related differences in the cortical motor readiness potential (Bereitschafts potential) involved in planning and accurate performance of discrete reaching movements in children and adults. *Methods*: Two groups of right-handed children (6- to 7- and 9-to 11-year-olds, each $n = 15$) and a group of adults ($n = 15$) performed a center-out drawing task to one of two targets (located at 135° and 315°) from a center (home) position. Targets and online visual feedback were provided on a computer monitor oriented at eye-level in front of the participants. For each of the 60 trials, participants self-selected a target, and after remaining still in the home position for 2 s, moved as quickly and accurately as possible to the target from the home position. Electroencephalography was recorded online during task performance from 11 cortical sites of interest (Fz, F3, F4, Cz, C3, C4, Pz, P3, P4, O1 and O2). Signals between 0.01 Hz and 100 Hz were collected using Grass model amplifiers at 512 Hz, with impedances below 10 kΩ. *Results and Discussion*: There were no group differences in movement length and RMSE, indicating all groups performed straight and accurate movements directly to the target. However, 6- and 7-year-olds moved significantly slower and their movements were less smooth than the 9- and 10-year-olds and the adults. Also, the initial movement direction was significantly more variable for the young children, as compared to the other two groups. Results from the event-related, time-averaged motor readiness potentials at Fz and Cz demonstrate that all groups exhibited increased negativity leading up to the initial phase of movement. *Conclusions*: The existence of adult-like brain patterns during motor performance may have contributed to the kinematic accuracy in both groups of children. However, several aspects of adult-like movement are still lacking in the performance of the young children. The faster, smoother, and more consistent performance of the older children and adults may have resulted

from the increased activation of motor areas, as indicated by increased negativity exhibited over the contralateral primary motor area. (This research was supported by NIH grants R01HD42527 and NIH RO3HD050372.)

Movement-Related Cortical Potentials in Blind and Sighted Subjects

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How do blind and sighted subjects represent their movements? Motor imagery has been widely used to infer about representational aspects of action. In this study, in order to investigate the contribution of vision on perspective taken during movement planning, we recorded the brain activity that precedes the mental simulation of a given action (readiness potentials - RP) in normal and blind subjects. Nine congenitally blind and 21 blindfolded sighted subjects were asked to execute right middle-finger extensions and afterwards either to imagine the same movement in first-person or in third-person perspectives. The last two blocks were randomized and each task was performed 50 times after a sound warning. EEG was recorded using 20 electrodes according to the 10/20 system (sampling rate of 600 Hz and the band-pass filter set between 0.05 and 35 Hz) and the electrode impedance was kept below 7 kΩ. Simultaneously, we acquired the myoeletric signal (extensor digitorum communis) and a load cell signal over the middle finger to register the beginning of movement during execution or its absence during the imagery conditions. As previously shown by Lehtokoski et al. (Neuroscience Letters, 253: 155-158, 1998), our preliminary results revealed larger RP amplitudes for the blind group in the Cz channel (corresponding most likely to supplementary motor area), in comparison to that of sighted subjects. In addition, RPs associated with imagining the movements in the first-person perspective was similar to that of execution in blind subjects, and clearly departed from that of the third-person perspective. Finally, in the sighted group there was no difference among the three tested conditions. In conclusion, despite their lack of access to visual information throughout life, congenitally blind people seem to use completely different strategies to simulate an action in the first- or third-person perspectives. In first person, RPs were similar to that of execution, suggesting that they were representing movements using mostly kinesthetic information. On the other hand, the lack of difference between the three conditions found for sighted subjects suggested that they might have used a visuo-kinesthetic strategy to perform the task. (Supported by CAPES-Cofecub, PRONEX, FAPERJ and CNPq.)

When Reaching For An Object, Which Hand Do You Use? TMS to Parietal Cortex Influences Hand Choice

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When reaching towards objects, for example to pick up a pen sitting on a table, a fundamental decision involves the selection of the hand to be used for the action. While we may not give much conscious thought to this decision, it is likely the result of complex computations that consider multiple sources of information. Evidence suggests that competing action plans may be activated to support reaches performed with either hand, and then some process is invoked to select between these options. Recent studies have pointed to loci in premotor and parietal areas involved in these planning and preparation processes. Here we used transcranial magnetic stimulation (TMS) to test the hypothesis that caudal intraparietal sulcus (IPS) is critically involved in the competition between action plans leading to hand choice. Participants performed reaches towards targets organized in a semi-circular array. With this arrangement, targets to the extreme right or left consistently elicit right- and left-hand responses, respectively. More ambiguity is found for targets close to the midline, with hand choice varying from trial to trial. We aimed to influence processes contributing to hand selection for unimanual reaching by applying single-pulse TMS 100 ms after the presentation of the target. We determined the point of subjective equality (PSE), the virtual location where the use of each hand was expected with 0.5 probability for each participant in three different conditions: stimulation to right IPS, stimulation to left IPS and no stimulation. We predicted that TMS would disrupt the activation of the action plan for the hand contralateral to the stimulated hemisphere, thus reducing the probability that this hand would be used. Based on previous studies, we expected that this influence might be asymmetrical as the left-hemisphere parietal activation appears to be more pronounced than the right-hemisphere activation. Our results supported our prediction. Stimulation to left IPS led to a significant decrease in the use of the right-hand (or increased use of the left-hand) relative to stimulation to right IPS and to the no-stimulation condition in 6 of 7 participants. While 5 of 7 participants also showed a decrease in the use of the left-hand following stimulation to right IPS relative to the no-stimulation condition, this change was not significant. Our results provide causal evidence that caudal IPS is involved in hand selection for manual reaches. We discuss these results in the context of current theories of action selection, hemispheric specialization and interhemispheric crosstalk.

Self-Organization in Sequences of Predictive Saccades

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Human subjects generate sequences of predictive saccadic eye movements when tracking periodically paced visual targets at a frequency above ~ 0.5 Hz. Tracking at lower frequencies produces reactive saccades with higher latencies. When target pacing monotonically increases or decreases, there is an abrupt transition between the two tracking modes (a phase transition). Several lines of evidence suggest that predictive saccade sequences are generated by an internal neural clock: inter-saccade timing is resistant to perturbations in stimulus timing, and distributions

of predictive intervals follow the scalar property (variability increases with inter-stimulus interval). Reactive saccade latencies are uncorrelated and resemble a white noise sequence. Predictive saccade latencies are correlated, so that the performance of previous saccades is taken into account in the timing of subsequent saccades. Consecutive predictive saccades are most strongly correlated over about 2 s; prediction is enabled when a sufficient number of previous saccades fall into this window, so that their timing error can be monitored. This explains the transition between reactive and predictive tracking. The correlations between predictive saccades decay gradually with time: the autocorrelation function decays as a power law, and the spectrum decays with a 1/f form. This suggests that the latencies form a fractional Brownian motion (fBm), which is a hallmark of self-organizing systems and demonstrates that there are variations in motor timing on multiple time scales. Variation on short time scales likely reflects monitoring of performance from trial to trial and represents the response to and correction of timing errors. Variation on longer time scales likely reflects monitoring of the characteristics of the stimulus and changing confidence in its long-term statistical structure. In particular, the longer a fixed stimulus pattern continues, the more confident the tracking system can be in using stimulus history in programming future behavior. This is seen experimentally in the fact that correlations between predictive saccades increase in temporal extent as the pacing stimulus continues. (This also leads to hysteresis in the phase transition between reactive and predictive tracking.) A final example of self-organizing behavior is that there is a tradeoff between reliance on previous saccade performance (inter-trial correlations) and reliance on the current stimulus, and this weighting changes as stimulus variability increases, showing a lesser dependence on internal timing (clock) as this clock deviates from incoming information on stimulus timing. Thus, saccade sequences exhibit not only predictive behavior, but also the ability to modify predictive properties based on experience. (Supported by NIH grants EY015193 and T32-MH20069, NSF BCS-0615106.)

Interlateral Asymmetry in the Execution of a Motor Response

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Introduction and Objective: There is some evidence in the literature about the dominance of the left hemisphere in motor control. In this study, a search was realized to investigate if this dominance can exercise influence in preparation of a response of a finger's movement. A simple reaction time task (SRT) was used that can include a prior preparation, and a choice reaction time task (CRT) where this preparation is not possible because the response is directly related when the target appears. *Material and Methods*: Twelve young women took part in each experiment. The task consisted of pressing one key as fast as possible when a disc appeared. This disc surged from the left or from the right side of a fixed central point. The response would be 1, 2, 3 or 4 movements in agreement with the trial blocks, in a way to provide an increase in motor difficulty. In the SRT, the volunteers should answer with the right hand in four trial blocks and with the left hand in another four blocks. In the CRT they should answer with the hand corresponding to the side where the target appeared. An audible stimulus came 200 ms before the main, approximately in half of the attempts in each block. This audible stimulus was during 50 ms and

the target 100 ms. *Results and Discussion*: The reaction time did not vary in a significant way in either task. In the SRT task, the time about submovements and pauses was longer in the left hand than in the right ($p < 0.04$), except in the last submovement and the last pause of the response of 4 submovements. In the CRT task, the first pause time was longer to the left hand than the right ($p < 0.001$). However, interlateral asymmetry was not found for other submovements and pause time. *Conclusions*: There are more efficient responses with the right hand than the left hand, especially in the SRT task. This suggests that the left hemisphere is more competent than the right to prepare a manual motor response. (Financial support was provided by FINEP, CAPES, and CNPq.)

Complex Motor Activity Patterns Evoked by Propioceptive Stimulation: Electromiographic and Kinematic Evidence of Motor "Primitives" in Humans?

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Prior work has put forward the hypothesis that complex movement is constructed by the combination of stereotypic motor patterns "stored" in cortical and spinal networks. Combinations of such "building blocks" could be selected by the motor cortices providing an advantageous computational procedure to rapidly plan and execute complex movements. In the current study we used propioceptive stimulation of specific body regions to elicit a set of stereotypical but highly complex involuntary motor patterns, providing EMG and kinematics evidence of their existence. A group of neurologically sound human subjects ($n = 4$) were positioned in supine decubitus with 30 degrees head rotation. Then they were constantly stimulated for 5 min with an anterior-to-posterior, lateral-to-medial and cephalic force vector applied digitally on the pectoral region between 6th and 7th intercostal spaces in the left hemiside. In a calibrated 3D space, kinematics coordinates of the contralateral ankle, knee, hip, shoulder, elbow and wrist and EMG correlates from the medial deltoids (DELT), biceps brachii (BB), external abdominal oblique (OBL), rectus femoris (RECT), tibialis anterior (TA) and semitendinous (ST) muscles were synchronously recorded. The results show a sequential pattern of involuntary muscle activations and movements starting with the OBL (45.1 s, post stimulus onset) and the ST (43.6 s), then the TA (53.1 s) and RECT (56.5 s), followed much later by the DELT (88.5 s) and BB (94.3 s). Kinematically, we observed a sequential and progressive pattern towards unilateral and/or bilateral tight flexion, leg extension followed by shoulder abduction, forearm flexion, and eventually wrist supination. Both EMG and kinematic activation chains were highly consistent within and across subjects. Repetition of each pattern at 5 min intervals for up to three times provided evidence of a progressive facilitation of the EMG response components, appearing earlier and reaching higher values. Subjects maintained consciousness

and normal cognitive abilities during the phenomena, but reported "feeling their extremities being manipulated like if they were puppets." All subjects were able to interrupt such induced involuntary patterns at will when requested. We conclude that propioceptive stimulation of body regions is able to elicit complex patterns of cortico-spinal "synergies" that might be used as modules by the motor cortices to optimally plan and execute movement.

Neurosensory and Cognitive Correlates of Cursive Writing

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Writing a graphic symbol deformed in a precise and time-ordered manner each muscle of a joint. This pattern of mechanical events evoked a specific pattern of lengthening and shortening of the various muscles generating a particular pattern of activity of the muscle spindle populations lying in these muscles. We assume that the proprioceptive feedback, as a whole, encodes the spatial and temporal characteristics of writing trajectories and that it will be sufficient to allow symbol recognition. The unitary activity of 60 muscle spindle afferents of the main ankle muscles was recorded using the microneurographic method during imposed writing movements. These activities were analyzed using the "vector population model." Muscle spindle afferents responded according to the tuning properties of the parent muscle, i.e., increasing their discharge rate when the direction of movement was within the preferred sensory sector of the parent muscle. The whole trajectory of the writing movements was coded by the activity of afferents arising from all the muscles of the joint. Both single and population afferent responses were found to be highly specific and reproducible with each graphic sign. The complex multi-muscle afferent pattern involved seems to constitute a "proprioceptive signature" for each graphic symbol. The ensemble of muscle spindle afferents were found to encode the instantaneous direction and velocity of writing movements with remarkable accuracy. Furthermore, the neuronal trajectories attained from populations of muscle spindles clearly depict the path and kinematic parameters and express the movement invariants, i.e., the trajectory segmentation and the relationship between velocity and curvature of a trajectory, i.e., the two-thirds power law. Finally, we investigate the contribution of muscle spindle feedback to proprioception and higher brain functions like movement trajectory recognition. For this purpose, writing illusory movements were evoked in subjects by applying, to each muscle group, patterns of tendon vibration mimicking the natural afferent pattern previously recorded. The results show that the afferent feedback of a given movement evokes the illusion of the same movement when applied to the subject via tendon vibration. The subjects were able to recognize and name symbols evoked by vibration in 83% of the trials. These findings suggest that the ''proprioceptive signature'' of a given movement is associated with the corresponding ''perceptual signature.'' The fact that the only ''proprioceptive signature'' of a graphic movement allows not only the perception of its trajectory but also its symbolic identification gives a character of cognitive nature to the proprioceptive messages coming from the writing hand.

Attentional Demands of Interlimb Interactions Underlying Rhythmic Bimanual Coordination

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To bridge the gap between the behavioral stability characteristics of rhythmic bimanual coordination and the underlying neurophysiological and psychological processes, we previously distinguished three sources of interlimb interaction, viz. integrated timing of open-loop control signals, corrections in timing based on perceived errors in relative phase, and phase entrainment by contralateral afference (Ridderikhoff, Peper, & Beek, 2005). These interactions differed with regard to their dependence on movement-elicited afference and their intentional nature (i.e., whether bimanual coordination was intended or not). The contributions of these sources of interaction to coordinative stability were successfully dissociated using a newly developed experimental design that entailed various rhythmic tasks (involving both passive and active wrist movements) in which these sources of interlimb interaction are engaged to different degrees. Several studies on rhythmic bimanual coordination have demonstrated that the stability characteristics are notably mediated by cognitive factors, like attentional demands (e.g., Temprado, Zanone, Monno, & Laurent, 1999). Because the proposed sources of interlimb interactions are assumed to invoke different neural systems (e.g., spinal and supraspinal), cognitive factors may be expected to affect the respective interaction sources to various degrees. The present study examined the effects of attentional demands on each of the three sources of interlimb interaction. To this end, the aforementioned experimental paradigm was modified to a dual-task design: participants performed the various rhythmic tasks both in isolation and while simultaneously performing a reaction time task. We hypothesized that the reflex-like phase entrainment by contralateral afference would be hardly affected by the secondary task, whereas the other two sources would be significantly influenced, resulting in less stable performance. Preliminary results were in agreement with this hypothesis: 1) the most pronounced effects of the secondary task were obtained for the afference-based timing corrections; 2) for the integrated timing of the open-loop control signal, the effects of the secondary task were less pronounced, mainly increasing the well-known stability difference between in-phase and antiphase coordination. These and other differential effects of the attentional load provided more insight into the relation between cognitive factors and the stability of coordinative patterns.

Migration of Cerebellar Neuronal Precursors Is Stimulated by a Synthetic Peptide Analogous to SDF-1/CXCL12 N-terminal

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During the development of the nervous system, neural progenitor cells migrate from the germinal epithelia where they are borne to their final destinations. The chemokine receptor CXCR4 plays a decisive role in physiological cell migration

both in developmental processes and adult tissues. Studies have shown that SDF1/CXCL12 regulates migration of cerebellar granular neurons, chemoattracts microglia, and stimulates cytokine production and glutamate release by astrocytes. In the developing cerebellum the expression of SDF1/CXCL12 is higher in the external granular layer than in the internal granular layer, creating a gradient of this chemokine. It has been proposed that this gradient would prevent the granule cells from leaving the external granular layer until the appropriate developmental timepoint. This suggested that early events in cerebellar granule cell morphogenesis, such as axon initiation, axon elongation, or migration of the cell body, might be severely perturbed in the absence of SDF1/CXCL12 signaling. Subsequently, it has been shown that CXCR4 null embryos also exhibit other phenotypes that reflect the abnormal migration of neuronal progenitors, including malformation of the dentate gyrus, lack of interneuron migration to the cortex, hypoplastic cortex and, most recently, malformation of the dorsal root ganglia. Mice deficient for the chemokine receptor CXCR4 show premature translocation of granule cell neuroblasts from their germinal zone into the nascent cerebellum. SDF1/CXCL12 is necessary for the normal development of the dentate gyrus, a forebrain structure crucial for learning and memory. To extend these observations, the activity of a synthetic peptide analogous to the N-terminus of SDF-1/CXCL12 on neuronal precursor migration and survival were examined in vitro. We first observed that migration of murine cerebellar neuronal precursors was stimulated by 3x10-7M of the SDF-1/CXCL12 analog as observed by real time in vitro assay. The peptide stimulated the percentage of migrating cells without affecting distance, duration or velocity of migration. On the other hand, the peptide was not able to promote neuronal precursors survival in the absence of KCl and growth factors. Taken together, our results indicate that we have synthesized a peptide analog to SDF-1/CXCL12 that is able to induce chemotaxis and random migration of cells that express CXCR4, but it does not promote neuronal cell survival. (Support provided by FAPESP, CNPq, FADA/UNIFESP, MCT/CNPq, DECIT/MS, Fundo Setorial de Biotecnologia (CT-Biotecnologia).

Characterization of Attentional Function in Elderly Adults Using Different Behavioral Tasks

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The poor performance of elderly people in a diversity of tasks has been partially attributed to age changes within one or more basic mental resources necessary for cognitive tasks. One of these resources is attention which can be defined as a neural activity that selectively facilitates sensory, cognitive and motor processing at each moment. The aim of the present study was to characterize more precisely the attentional deficiencies in elderly people. We assessed covert automatic attention, voluntary attention, selective attention, and divided attention using reaction time tasks. Two groups of 15 individuals, literated, with punctuation of at least 26 in the Mini Mental Exam were tested. Group 1 was constituted of men and women

between 25 and 45 years old, and Group 2 had the same proportion of men and women between 60 and 80 years of age. Automatic attention was mobilized by a peripheral visual stimulus, spatially non-informative, and voluntary attention by a symbolic central cue. Selective attention was tested with the presentation of central distracter stimuli and divided attention by the presentation of two simultaneous stimuli. There were no significant differences between the two groups for automatic attention. Voluntary attention and selective attention tended to be worse for Group 2. Divided attention has been shown to be clearly deficient in Group 1 ($p < 0.01$). The aging process compromises the most complex aspects of attentional function. This dysfunction would amplify the well known sensory and motor deficiencies of elderly people, contributing to the progressive loss of functional independence that they present.

Evidence of Plateau Potentials in Foot Muscle During Quiet Stance

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Introduction: Evidence of a self-sustained muscle activation following a brief electrical stimulation have been reported in the literature. The main cause seems to be the genesis of motoneuron plateau potentials in response to a train of postsynaptic potentials. This self-sustained muscle activity could be useful in posture-muscles. Nozaki et al. (2003) showed self-sustained phenomena in the soleus muscle in subjects in a supine position. Regarding posture, muscles of the foot have also been shown to have at least an auxiliary role. The purpose of this study is to demonstrate that train stimulation induces a sustained muscle contraction that outlasts the stimulation period at the muscle flexor digitorum brevis (FDB) in quiet stance. *Method*: Healthy subjects were requested to stand upright for 40 s. Surface EMG electrodes were placed on the following muscles: FDB, soleus and tibialis anterior of the right leg. After 20 s of background muscle activity (BGA) acquisition, a 50 Hz train of stimuli (2 s train duration, with 1 ms pulses) was applied to the tibial nerve at the popliteal fossa. Each subject normally performed three trials each. In order to avoid fatigue, each condition was performed after a 2 min resting interval. The BGA and the self-sustained muscle contraction (after the electrical stimuli) were quantified by the root mean square value (RMS). Student's *t*-test was used to compare both situations ($p < 0.05$). *Results*: Preliminary results demonstrated a sustained electrical muscle activity in the FDB after the train stimulation was turned off. There was an average of a 40% increase in amplitude with respect to that of BGA. At the same time, EMG activity of the soleus and tibialis anterior did not change post-stimuli, and maintained the same RMS value as at BGA (before electrical stimulation). *Conclusion*: We hypothesize that the sustained muscle contraction induced here is evidence of the occurrence of plateau potentials in the FDB spinal motoneurons. This phenomenon should be further investigated with respect to the impact of such a sustained contraction in postural control.

Synchronization Among Lateral and Long Head of the Triceps Brachialis by Surface Electromyography

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Studies with surface electromyography (SEMG) of the lateral (TLa) and long head (TLo) of the triceps brachialis muscles can be conducted to test the importance of the each muscle during elbow extension. Usually, the SEMG amplitude is related to what is considered to be a possible lag of the SEMG activity among muscle. The purpose of this work was to test the existence of the time lag among TLa and TLo myoelectrical activity during elbow extension. Twenty healthy males (age 18-24 years) accomplished concentric and eccentric muscular contraction in the elbow extension exercise at a pulley machine. The amplitude of the movement was 90 to 180 degrees and cadence equaled one cycle at each 3 s, until voluntary fatigue. Electromyographic signals were collected by superficial disposable Ag/AgCl electrodes fixed on the TLa and TLo, at 50% of the distance between the acromion and the olecranon. Initially the subjects were submited to a one repetition maximum test (1 RM) and after 5 min the SEMG acquisition of the TLa and TLo was carried out with 80% of the weight related to the 1 RM. SEMG was digitized at 2 kHz through a analog-to-digital converter, with 16 bits resolution and a dynamic range of ± 5 V. SEMG signals were pre-processed to remove movement artifacts and high frequency noise, besides attenuate 60 Hz harmonics until 360 Hz. Two Butterworth, low-pass 8th order filters with a cutoff frequency of 400 Hz and high-pass 2nd order filters with a cutoff frequency of 10 Hz, were used to delimit the bandwidth of the signals. For attenuating 60 Hz noise and its harmonics, a six stop-band 2nd order Butterworth digital filter was centered on 60 Hz harmonics until 360 Hz. After signal decimation to 1 kHz, the root mean square (RMS) values were calculated (100 ms time window). Normalized cross-correlation function (NCCF) was estimated among RMS values of the TLa and TLo and time lag of the maximum NCCF was considered and estimated of the latency among signals. Student's *t*-test was applied to test the null hypothesis that mean time lag is zero ($\alpha = 0.05$). The maximum correlation and time lag were 0.74 ± 0.11 (mean ± standard deviation) and -0.07 ± 0.20 s. Therefore, the time lag was not significantly different than zero ($p = 0.17$). The present study indicates that TLa and TLo activate in perfect synchronization.

Presynaptic Inhibition of Alfa-Motoneurons in Athletes During Different Muscular Activity

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Seventy-six male athletes, 19 to 22 years old, took part in the research. These were sprinters, stayers, sambo wrestlers, and skiers, with various qualifications. The method of assessment of the presynaptic inhibition (PI) of homonymous and heteronymous Ia afferent fibers going from m. soleus (Sol) and m. quadriceps femoris (QF) to the Sol alfa-motoneurons MNs was used (Hultborn et al., 1987). The PI of Sol MNs was also assessed by the degree of Sol H-reflex amplitude suppression during vibration stimulation of t. calcaneus, and its recovery after the exposure (Anisimova et al., 1987). In order to reveal changes in the PI of Sol MNs

under motor activity of various nature, sambo wrestlers performed the following motor patterns. In the first series, the athletes performed ten repetitions holding a 40 kg load in the back-lying position, by means of the plantar flexion of the foot; in the second series, they performed ten repetitions holding a load equal to 70% of the maximum voluntary contraction (MVC) until a failure in each attempt; in the third series, the technical (TT) and strength (ST) training was performed. The PI was recorded at rest, after the third, sixth, and tenth static load attempts, at the fifth and tenth minute of relaxation, and after TT and ST. It was revealed that under homonymous and heteronymous conditioning stimulation of n. tibialis and n. femoris in the relative muscular rest condition, the PI of Sol spinal cord MNs is more significantly expressed in sambo wrestlers and sprinters than in stayers. This fact is evidence that adaptation to muscular work of various nature affects the mechanism of PI of the spinal cord MNs. The PI of Sol spinal cord MNs under homonymous vibration stimulation of t. calcaneus in the relative muscular rest condition is significantly more expressed in sambo wrestlers as compared to stayers. In the after-vibration period, the PI of the spinal cord MNs reaches the initial level faster in sambo wrestlers than in people training for endurance development. Highly qualified sambo wrestlers are described with more expressed PI of Sol Ia afferent fibers and QF primary afferent fibers under homonymous and heteronymous electric stimulation and vibration exposure, which is evidence of the PI mechanism's dependence on the athletic qualification level.

Performance in Simple and Choice Reaction Time Tasks of Different Complexities

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Introduction: It has been shown that the time needed to program a motor response depends on its complexity. This study compared the latencies of responses constituted by two, four, six and eight submovements in a simple reaction time task (SRT) and a choice reaction time task (CRT). *Method*: Sixteen right-handed young adults performed each task. They did four testing sessions separated by an interval of one month. Two, four, six or eight submovements, in a pseudorandom order, were required each time. In these sessions, a target stimulus was presented on the left, right or left and right sides of a fixation mark located in the center of a monitor screen. The SRT group responded to this stimulus with the left hand in one block of 21 trials, with the right hand in another block of 21 trials, and with both hands in another block of 21 trials, also in a pseudorandom order. The CRT group responded to the left hemifield stimulus with the left hand, to the right hemifield stimulus with the right hand and to the bilateral stimulus with both hands, in each one of the three blocks. *Results*: Reaction time was longer for the CRT task than for the SRT task ($p < 0.001$). In both tasks reaction time increased with the number of submovements. In the SRT task, the eight submovements-response started later than the two submovements-response ($p = 0.044$). On the other hand, in the CRT task, the six and eight submovements-responses started later than the two submovements-response (respectively, $p = 0.007$ and $p = 0.001$); the eight submovements-response started later than the four submovements-response ($p = 0.043$). In the CRT task, the bilateral response started later than the unilateral condition ($p < 0.001$). *Conclusion*: These

findings indicate that motor programming duration for both simple and choice tasks increases with the number of submovements of the response.

Manual Asymmetries and the Effects of Task Complexity on Simple Reaction Time

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Some manual asymmetries studies have pointed out that the left hand enjoys an advantage over the right hand in reaction time (RT), attributing this advantage to the right hemisphere specialization for localization of targets and limbs, prior to the organization of the movement. Few studies investigated the relation between manual asymmetry and task complexity on RT. Therefore, the aim of the present study was to verify the effect of task complexity on motor programming in both hands through simple reaction time (SRT) measure. Thirty-two right-handed participants (age ranging from 18 to 35 years) were randomly assigned for one of two experiments (n = 16): Exp1 –SRT task with different effector complexities; Exp2 – two SRT task with different spatial complexities. Exp 1 consisted of performing two tasks: 1) a simple task, which consisted of releasing a push-button as quickly as possible after a visual stimulus; 2) a complex task, which consisted of releasing a push-button as quickly as possible after a visual stimuli and positioning a tennis ball into two recipients in the ipsilateral hand workspace. Exp2 also consisted of performing two tasks: 1) a simple task, which consisted of releasing a push-button as quickly as possible after a visual stimuli and positioning a tennis ball into two recipients in the ipsilateral hand workspace; 2) a complex task, which consisted of performing the same task but in contralateral hand workspace. In all conditions both hands performed the tasks. Data analysis was carried out through a two-way ANOVA and Tukey post-hoc test. In Exp1, the analysis did not show significant difference for Hands, as well as for Hands × Complexity interaction ($p > 0.05$), but detected significant difference for Complexity [$F(1,30) = 16.60$, $p < 0.01$] indicating a lower SRT to the simple task compared to the complex task. In Exp2, the analysis detected no significant difference for Hands, as well as for Hands × Complexity interaction ($p > 0.05$). However, it detected a marginal difference for Complexity [$F(1,30) = 3.34$, $p = 0.07$] indicating a tendency to a lower SRT for both hands in the right workspace compared with the left workspace. These results did not indicate manual asymmetries on SRT in function of the task complexity. Further research is suggested to investigate manual asymmetries and the effects of task complexity on choice reaction time.

The Effects of Cortical Cell Assemblies on Isometric Force Production

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Parameter precuing is a technique for studying motor programming. In this technique, partial or complete information about the response are presented in advance

of a stimulus. The numerous experiments using this technique have shown that the precues reduce the reaction time; the mechanisms by which this reduction is achieved, however, remain disputed. The present study was performed in order to test the hypothesis that RT is a function of degree of the overlap of muscle neuronal representations in the motor cortex of the brain. Therefore, in spite of previous studies that had not controlled the effect of the nature of precues, this factor and the effect of the degree of overlap of cell assemblies were independently varied and investigated. Therefore, a mixed three factorial design was performed on 16 (8 male and 8 female) non-athletes and right-handed students in age range from 20-25 years. The participants performed two blocks of 60 trials under two conditions by parameter precuing apparatus. In two conditions, the precue was the same (limb), but the degree of overlap of cell assemblies was low and high, respectively. The effect of the order of experimental conditions was controlled by counterbalancing. In condition 1, the task required production of 3 or 6 kg isometric force with right or left upper limb toward the outside and in condition 2, the task was production of 3 kg force with right or left upper limb toward the inside or outside as quickly and accurately as possible after displaying precue followed by stimulus. RT of isometric force production was measured and analyzed by 2 (Order) × 2 (Overlap) × 60 (Trials) ANOVA with repeated measures on the last two factors. The results indicated the significant main effects of the degree of overlap of cell assemblies and trials ($p < 0.01$); but the main effect of order and interaction of the factors were not significant ($p > 0.05$). The mean of RT of condition 1 (553.4 ms) was significantly more than condition 2 (538.4 ms). Therefore, RT in this task was a function of degree of overlap of muscle representations in the motor cortex, and these findings supported the cortical cell assembly theory of motor programming (Wickens, et al., 1994).

The Mechanisms of the Effect of Precue on the Stages of Sensorimotor Processing

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Parameter precuing is a technique for studying motor programming. In this technique, partial or complete information about the response are presented in advance of a stimulus. The numerous experiments using this technique have shown that the precues reduce the reaction time; the mechanisms by which this reduction is achieved, however, remain disputed. The present study separated the effect of the number and of choices and the nature of precues on reaction time (RT) for the purpose of investigating the effect of precues on the stages response selection and motor preparation of sensorimotor processing. Therefore, the experiment was performed on 24 right-handed students in age range 18-24 years. The participants repeated three precue (2-choice direction precue, 3-choice direction precue, and 2-choice force precue) and 1 control (non-precue) conditions 30 times with random order after performing 200 training trials by parameter precuing apparatus. RT of isometric force production was measured and analyzed by 4 (Condition) × 30 (Repetition) repeated measures ANOVA. The results indicated the significant main effects of number of alternatives and precued parameters ($p < 0.01$); but the main effect of repetition and interaction of two factors were not significant ($p > 0.05$).

The results of this experiment indicated that precues reduce RT by involving of response selection and motor preparation stages of sensorimotor processing.

Influence of the Exercise in the Plasticity of the snc After Injury: Physical Activity Modulates Astrocytic Activation and Dendritic Arborization of Rats Submitted to the Ischemia

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Objectives: Analyze the influence of the spontaneous physical activity in the processes of astrocytic activation and the disappearance of dendrites of rats submitted to the focal ischemic lesion. *Methods*: Male Wistar rats had access to the running wheel for seven periods of 12 hours before the injury. Sedentary animals stayed in same situations in individual cages without wheel. Exercised (EXE) and some sedentary (SED) rats were submitted to a stereotaxical injection of endotelin-1 (ET-1, 2 μg) in the left striatum for focal ischemia. Other sedentary rats received injection of solvent (control, CTR). After the surgery, the exercised animals were divided in two groups: interrupted exercise (IEXE, without further access to wheel) and maintained exercise (MEXE, with further access to wheel). After 14 or 30 days of the injury, the animals were sacrificed and their brains processed for the glial fibrillary acidic protein (GFAP, marker for astrocytes) and microtubule associated protein-2 (MAP-2, marker for dendrites). The area of immunoreactivity of the GFAP and MAP-2 around injury and in the corresponding area of the contralateral striatum had been quantified by means of the morphometric analysis (KS400, Zeiss). *Results*: Fourteen days after lesion, a bigger area of astrocytic activation around the injury was observed in the CTR (230%, $p < 0.05$), SED (142%, $p < 0.05$) and IEXE (174%, $p < 0.05$) in relation to the contralateral corresponding region. On 30th day after lesion, it still had greater astrocytic activation around the injury in the CTR (87%, $p < 0.01$), SED (128%), IEXE (130%, $p < 0.05$) and now in the MEXE (79%, $p < 0.05$) in relation to the contralateral region. Additionally, the MEXE presented an important increase ($p < 0.001$) of the astrocytic activation in the striatum, bilaterally, in relation to the other groups. Reduction of the area of immunoreactivity of the MAP-2 was observed in the lesioned striatum in relation to the contralateral only in the SED (52%, $p < 0.001$) on 14th day. This reduction was observed in the SED (52%, $p < 0.01$), IEXE (63%, $p < 0.05$) and MEXE (34%, $p < 0.05$) on 30th day. The inter-groups analysis, on 14th day, showed a minor area of immunoreactivity of the MAP-2 in the lesioned striatum of the SED in relation to the IEXE (48%, $p < 0.05$) and MEXE (62%, $p < 0.05$). The same analysis on the 30th day showed a greater area of immunoreactivity of the MAP-2 on MEXE ($p < 0.01$), bilaterally, in relation to the other groups. *Conclusion*: The spontaneous physical activity can modulate astrocytic activation induced to the ischemic injury, as well as reduce the disappearance of dendrites around the injury and promote the increase of the contralateral dendritic arborization. These are some of the mechanisms responsible for the benefits of exercise in the plasticity of the central nervous system after injury.

The Orienting of Visual Attention and Time Perception in Idiopathic Parkinson's Disease Patients and in Healthy Aging

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Objective: To assess the effects of Parkinson's disease (PD) and healthy aging on voluntary visual attention and temporal order perception. *Methods and Results*: Two psychophysical experiments were performed. In experiment I, we studied the voluntary orienting of visual attention in a reaction time (RT) task. The subjects oriented their attention to an informative cue and responded as fast as possible to a target. We observed that PD patients had increased RT when compared with elderly and young subjects. In experiment II, we evaluated detectability (d') in a temporal order judgment task (TOJ), wherein two visual stimuli were presented with different intervals. The volunteers judged which stimuli appeared first. We observed that when the interval between stimuli decreased, 1) the young subjects maintained the d'; 2) the elderly subjects had a decreased d' in all intervals; and 3) the PD patients had the fastest decline of d' and reached the smallest values. Comparing the RT values and the ratio of correct responses in the TOJ task, we found a positive correlation between them. *Conclusions*: Aging induces deficits in voluntary visual attention and temporal order discrimination, which are more evident in PD. The positive correlation between the results of these two tasks suggests common mechanisms involving perceptual and motor aspects.

Action Prediction in Unilateral Upper-Limb Amputees

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Mirror neurons, described in the monkey's F5 motor area and in the parietal cortex, are active during movement execution but also when the animal watches the same movement performed by another animal or the experimenter. Recent neuroimaging studies have claimed that a similar neural execution/observation mechanism might also exist in humans. This system was also implicated in the prediction of another person's movement (Nat Neurosci. 7(12):1299, 2004). Here we evaluated if this capacity was affected by an upper-limb amputation. We recorded the readiness potential (RP) while subjects watched a movie where, after 2.0 s, an actor grasped a green object (Mov_obs). In another video, the object was red and the actor's hand remained stationary (NO-MovObs). Thus, the subject could predict from the color of the object if the movement was going to occur or not. Four patients with unilateral upper-limb amputation were tested (two left and two right-sided) as well as eight control subjects. The electroencephalography was recorded with

a 65-channel Geodesic Sensor Net. Electromyography was recorded from the first dorsal interosseous to ensure that no overt movement occurred. Data was analyzed offline in Matlab 6.5. The RP slope was calculated using linear regression in a window of interest between 2000 and 500 ms before movement onset. Statistical significance was tested by means of two-way ANOVA and Fisher LSD post hoc test. As expected, the RP negativity was found before movement onset in the Mov_obs condition, but not when subjects did not expect the grasping movement to occur (NO-MovObs condition), ($p < 0.01$). Furthermore, there was an interaction between experimental conditions and groups ($p = 0.05$). Post-hoc analyses demonstrated that the difference between the Mov_obs and NO-MovObs condition occurred both for the control group ($p < 0.01$) and for the amputees when they had to predict the impeding action performed with a hand corresponding to their intact hand ($p = 0.05$). However, this difference disappeared when amputees had to predict an observed hand movement on the side corresponding to their amputation ($p = 0.99$). The absence of a RP in the Mov_obs condition for the amputated side and its preservation in the spared side found in amputees suggests that the motor and sensorial information about their own arm plays a key role for the RP generation and even movement prediction in the context of movement observation. Thus, cortical reorganization that follows amputation of a limb seems to impair the motor anticipation of the corresponding limb. (Acknowledgements: Pronex, Capes-cofecub, CNPQ, FAPERJ, NSF.)

Effects of Spontaneous Running in mrna BDNF Expression in Rat Hippocampus and in Anxiety and Memory Responses Through an Elevated T-Maze

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Objective: Physical activity influences brain trophism and plasticity. The aim of this study was to evaluate the effects of voluntary wheel-running on anxiety and memory responses through an elevated T-maze. Molecular changes were also to be evaluated like the expression of BDNF mRNA in the hippocampal formation using in situ hybridization. *Methods and Results*: Young Wistar rats (age 21 days) were placed in individual cages with free access to running wheels for 5 weeks (trained), and rats were placed in individual cages in the same room, without running wheels (sedentary). Immediately after 5 weeks of voluntary wheel-running animals were tested in an elevated T-maze for memory and anxiety. Rats were decapitated immediately after 5 weeks of voluntary training regime and the brains were submitted to in situ hybridization to analyze changes in mRNA expression of brain-derived neurotrophic factor (BDNF) in hippocampus formation. Voluntary wheel-running enhances performance in learning of inhibitory avoidance, and decreases anxiety level in elevated-T maze. Five weeks of exercise increased the expression of mRNA of BDNF in dentate gyros and CA3 area of hippocampus formation. *Conclusion*: Voluntary wheel-running promotes plasticity in limbic areas, like hippocampus formation, influencing the mechanisms of learning and anxiety.

eqlb Mutation Mapped to Mouse Chromosome 17 Causes Abnormal Cerebellar Development and Ataxia

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Several human diseases currently known are of genetic cause. One way to understand the molecular alterations that lead to a given disease is through the analysis of gene dysfunction, which can be done using animal models that recapitulate such pathologies. The mouse performs this function very well, because there is a high percentage of homology between its genome and that of man. Spontaneous or chemically induced mutations are useful to elucidate how a mutated gene gives rise to a given illness phenotype. Although the current mouse mutant database, which is composed largely of knockout animals, has been a valuable source of models, only a small proportion of the likely total number of mammalian genes is represented. This gap is being partially filled by the establishment of new mutagenesis programs using potent mammalian mutagens like N-ethyl-N-nitrosourea (ENU). Through an ENU mutagenesis project, recessive mutant mice bearing varied phenotypes were isolated, one being a mutant mouse presenting balance problems, with characteristics of lack of motor coordination, named equilibrio (eqlb). The phenotype led us to hypothesize that the generated mutation could be affecting the development of the cerebellum region of the central nervous system that controls the execution of movement and balance. The evaluation of mutant and wild-type adults behavior in the test of permanence on a rotating bar showed that the time of permanence of eqlb females was significantly diminished in relation the wild-type females. The performance of the eqlb males in the rotarod test was worse than wild-type mice, although better than female mice, suggesting that females could be more affected than males. Histological analysis of eqlb mice cerebella shows abnormal formation of the cellular layers, with disorganization of the Purkinje cell layer, the main type of neuron in the cerebellum. Histological analysis also revealed that the external granular cell layer is thicker in eqlb mutant mice, when compared to same age wild-type mice cerebellum. [3H]-Thymidine incorporation showed that the proliferation rate was higher in eqlb mutant cerebella. There are no differences between eqlb and wild-type granule neurons migration rate, followed by BrdU incorporation. Mapping of the mutation, using polymorphic microsatelite markers, indicates that this mutation is located on mouse chromosome 17, in a chromosomal subregion between the marker D17Mit267 (3.31Mb) and the centromeric edge. The next step will be to carry through new experiments in order to finally determine the mutated gene using positional cloning techniques.

Kinesiology and Biomechanics

The Influence of Age and Task Demands on the Ability to Utilize Proprioceptive Feedback in Right Hand Dominant Individuals

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Proprioceptive feedback arising from muscle, joint, and cutaneous receptors is critical for the control of coordinated limb movement, postural stability, and the learning and adaptation of goal-directed functional activity. Previously, we have shown that the ability to utilize somatosensory feedback for upper limb position matching tasks declines with age (Adamo et al., in press). Based on our knowledge of cortical plasticity, it is known that motor training can improve upper limb function in neurological populations but to what extent task-specific activity preserves proprioceptive function in the elderly is not known. The purpose of this study was to examine the influence of age and task demands on the ability to utilize proprioceptive feedback in older adults and determine if performing tasks specific to the upper limbs contributes to these differences. Twelve young (age 22-30 years) and 30 older (> 70 years) adults participated in the study with the elderly classified into two groups according to the frequency and duration of daily upper limb activities (upper limb specific: $n = 13$, non-specific: $n = 17$). Participants performed proprioceptively-guided, 40 degree wrist extension movements in the absence of vision. The reference position was generated by passive displacement of the wrist and participants then matched the reference position with the same (ipsilateral remembered) or opposite (contralateral concurrent and contralateral remembered) wrist. Matching movements were made by the both the right dominant and left non-dominant limb. The ability to reproduce limb position using only proprioceptive information was significantly reduced in elderly compared to young individuals ($p < 0.001$). Position matching errors were 21% greater in older adults who showed less upper limb usage in everyday tasks compared to individuals who used their upper limbs to a greater extent ($p = 0.02$). These differences were most pronounced in matching tasks which required interhemispheric transfer of the reference position. ($p = 0.05$). In all groups, matching errors were greater in the right than left hand ($p = 0.01$) and when matching was performed by the opposite than with the same hand ($p = 0.01$). This study shows that preferential upper limb use in older adults enhances proprioceptive ability through recurrent activation of

sensorimotor pathways. This may also involve a facilitation in activity-dependent, interhemispheric transfer of movement-related somatosensory information, particularly in bilateral tasks. (Supported by University of Michigan Institute of Gerontology National Institute on Aging T32 training grant (AG00114) to DA, and a National Institute on Aging R03 grant (AG 025120-01) to SB.)

Manual Asymmetries and Task Complexity in Aiming Movements

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An influence factor in manual asymmetries (MA) is task complexity. Nevertheless, in behavioral studies, task complexity has not often been investigated directly due to the different nature of the tasks. Moreover, divergent results concerning MA are found in the literature. Results of behavioral studies point to an increased level of asymmetry in more complex tasks, while results of neurophysiological studies indicate that MA decreases in more complex tasks due to the more accentuated bihemispheric activation. This study investigated MA in aiming tasks with different complexities. Complexity was defined according to the number of task components: 1) simple task (discrete movement to one target) and 2) complex task (serial movement to two targets). Ten right-handed participants were required to make rapid goal-directed movements, five trials of both tasks with both hands, in the ipsilateral space to small targets (1.5 cm in diameter). The distance between each aiming point was 20 cm (ID = 4.74 bits). Movements were recorded at a sample rate of 400 Hz (Simi Motion 7.0). Anovas (2 hands × 2 complexities) and Tukey's test were used ($p \leq 0.05$). Results indicated effect of task complexity to reaction time, contact time to the first target (movement time), peak velocity to the first target, proportional time to reach the peak velocity to the first target. MA was found in both tasks to response time and number of corrections after the peak velocity to the first target. These results indicate that the tasks were different in terms of complexity and that the levels of asymmetry were equal in both tasks. Therefore, the effect of task complexity on MA was not found. This result contradicts previous findings and may be explained by the task features. First, behavioral studies that used tasks with different natures evaluated not only the task complexity, but also other influence factors on MA, making a more precise analysis difficult. Second, in studies that indicate less pronounced asymmetries in complex tasks, a usual characteristic of the tasks is the few degrees of freedom (DF) involved in the control of finger movements. Tasks that involve more DF may present different levels of cortical activation between brain hemispheres compared to the tasks with few DF. In short, these results can be discussed in relation to the restricted generalization of previous findings on MA and task complexity.

Motor Adjustments in Landing Movements Under Acute and Chronic Vision Absence

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The landing movement is a convenient model for the study of several fundamental aspects of motor control, and has been studied both in humans and other animals, attempting to infer how visual, vestibular and proprioceptive information are integrated, during this task, to allow a safe and effective absorption of kinetic energy after touchdown. However the possibility has not been explored that these interactions may be modified in special cases, when adaptation mechanisms in these sensorial systems can be present, such as in a chronic blindness. The aim of the study was to assess the adaptation of motor and sensitive systems, when proprioceptive and vestibular information substitute for the acute and chronic lack of vision in adapting landing movements, by quantifying and comparing kinematics and electromyographic (EMG) (100 ms before and 100 ms after touchdown) variables between subjects with the presence of vision, with a momentary absence of vision (blindfolded), and with chronic blindness. Ten subjects were asked to land from drops of 0.2, 0.3, 0.4 and 0.5 m (six consecutive drops for each height) under two experimental conditions: with vision (experiment 1) and without vision (blindfolded) (experiment 2). In experiment 3, five chronic blind volunteers were submitted to the same task. The EMG activity of the lateral gastrocnemius (GL), tibialis anterior (TA), vastus lateralis (VL) and semitendinosus (ST) muscles was recorded using bipolar surface electrodes. An electrogoniometer was also used as a way to measure the angle variation of the knee joint. It was found in some situations, for both groups 2 and 3, mean timing EMG and RMS values (pre and post landing) being different from the same ones found for group 1 during the first drop of the six repetition series, which could, by an adaptation mechanism, be similar to the values found for group 1 starting from the second drops. On other occasions, however, such differences were observed along consecutive drops. So, the results suggest that vision is important for modulating muscle activity amplitude during landing, as it seems that non-visual sensory information could not fully compensate for the lack of continuous visual feedback in the subjects with a momentary absence of vision. On the other hand, the chronic blindness subjects seem to use different strategies, modulating the motor task in a distinct manner, when compared to the other groups.

Motor Cortex in the Natural and Learned Bimanual Unloading

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Anticipatory postural adjustments (APA) during bimanual actions can be observed when participants hold an object in one hand and then lift it with the other hand. The changes in the activity of a forearm flexor muscle prior to an active forearm unloading acted to stabilize the forearm position. Our recent studies have investigated the influence of the corticospinal system on motor output during APA by means of transcranial magnetic stimulation (TMS). It was shown that the amplitude of motor evoked potentials in the forearm flexor at different times during APA decreased with the decrease of muscle activity. If the unloading is triggered via electromagnet, the anticipatory postural adjustment learned through the experimental learning session (three series of 20 trials). Using TMS we examined changes in the motor evoked potential in the forearm flexor during initial and final

sessions of APA learning. Motor evoked potential amplitude did not significantly change in the process of forearm flexor activity decrease. However, motor evoked potential/background electromyogram ratio at the final learning session increased in comparison with the initial learning session and with the stationary loading. The present results highlight the fundamental role of motor cortex in the depression of the synergies that interfere with the execution of the new coordination in the process of motor learning.

Attention, Amplitude, and Asymmetry in Interlimb Coordination

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In human bimanual behavior, perfect symmetry is the exception rather than the rule. A typical asymmetry during rhythmic bimanual coordination is that the dominant (D) limb leads the non-dominant (ND) limb in time. Interestingly, directing (visual) attention to either limb has been shown to affect the relative phase dynamics in a manner comparable to handedness. From the perspective of coordination dynamics, these effects have been considered to result from an asymmetry in the strength of the interlimb coupling (e.g., the ND limb being influenced more strongly by the D limb than vice versa), which, theoretically, may improve the stability of coordinative performance. Alternatively, on the basis of recent results, we hypothesized that attention-induced relative phase asymmetries may also be engendered by an accompanying difference between the amplitudes (and hence the preferred frequencies) of the limb movements. We conducted three experiments to examine those (not mutually exclusive) potential effects. Controlled manipulations of amplitude disparity and attentional focus, both alone and in conjunction, revealed that variations in amplitude disparity had the expected effects on the relative phasing between the limbs. However, no compelling evidence was obtained for the interpretation that attentional asymmetry affects (the stability of) the relative phasing through an asymmetry in coupling strength. Together these results indicated that, indeed, the effects of asymmetric attentional focus on the interlimb phasing results from (unintended) variations in the movement amplitudes of the individual limbs (with the attended limb's amplitude being larger than that of the unattended limb). On a more general note, this study demonstrated that the analysis of rhythmic bimanual performance in terms of the compound effects at the level of the relative phasing alone is not always sufficient and may even hamper interpretation of the data, thereby underscoring the importance of complementary analyses of both the coupling and the component dynamics.

Tactile and Visual Cues Effect in the Intonation Control of the Double Bass: Undershoot and Overshoot Patterns on Target Notes

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The non-tempered orchestral stringed instruments (e.g., violin family) have no frets on their fingerboards creating uncertainty about the exact point for the positioning of the left hand's fingers. Slightest variations in the fingers pointing deteriorate intonation because movements home in before (undershoot) or after (overshoot) the target location on the fingerboard. One of the factors that would affect undershoot or overshoot patterns is the type of sensorial information available. Lage, Borém, Vieira and Barreiros (in press) found a high level of accuracy and consistency in double-bass performance when tactile and visual cues (TVC) were available (verbal instruction to use specific physical contours as tactile cues to anchor parts of the upper left limb; visual marks to produce a physical reference on the fingerboard). The goal of the present study was to investigate the effects of TVC on undershoot and overshoot patterns in double-bass intonation control. Seven non-tempered musicians took part in the experiment. An atonal sequence with isolated 11 target notes having no intended musical meaning was played in two different conditions by the participants: 1) Free Trial (FT) with participants performing without TVC, and 2) Integrated Trial (IT) with participants instructed to perform based on TVC (three tactile search points located in three places of the instrument body; three Visual Search marks signaling the intervals of fifth, octave and octave plus fifth from the open strings). Audio signals were recorded in a computer, the fundamental frequency (Hz) of each note was measured by customized software and the estimated values were subtracted from the target values (error). Errors were organized into two blocks of trials (FT and IT), each block having 11 notes, constant error and the standard deviation were computed in five ascending notes (AN) and six descending notes (DN). Wilcoxon tests were performed ($p \leq 5\%$). The results showed patterns in opposite directions when analyzed all 11 notes ($p = 0.02$) and when analyzed the DN ($p = 0.01$). A marginal difference was found to AN ($p = 0.06$). Participants produced undershoot pattern in FT and overshoot pattern in IT. Different levels of certainty to achieve target notes seem to lead to different cognitive strategies in motor control. Further research needs to be carried out to analyze the musician's common perception in which playing out of tune below the notes (undershoot) is preferable than playing out of tune above (overshoot) the notes in situations they feel less confident and not so sure about their intonation.

Dependence of Task Performance Accuracy Upon the Number of Degrees of Freedom at the Effector Level

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How does the accuracy of task performance depend upon the number of the explicitly involved effectors? Published experimental results are contradictory. An increase in the magnitude of force F has been shown to lead to a close to linear increase of its standard deviation SD (analogous to the Weber-Fechner law in the area of perception). We model this relation as: SD(F) = aF +b. We assume that each element within a multi-element system obeys this equation. Then, if several (N) elements act together to produce a common effect, for example, during multi-finger force production (in this case, N is degree of freedom), the production of an individual element depends on N. If the elements share the total force equally, Fi = Ftotal/N. This can lead to a drop in the SD of the total force with an increase in the number of fingers involved, even without any additional co-variation among finger forces. For example, assuming the intercept b = 0, if the total force remains constant, in a two-finger task each finger is expected to produce 50% of the force as compared to a one-finger task. This is expected to lead to a drop in the SD of the total force by about 30%. Further increase in the number of fingers may be expected to lead to a further (but smaller) gain in force accuracy. However, if b is not zero, the relation between force variability and the number of involved fingers may be non-monotonic and have a minimum for a certain number of finger:

$$SD(Ftotal) = Sqrt(N)(aFtotal/N+b)$$

Hence, a change in the number of effectors can produce a change in indices of variability of the output of the system without any co-variation patterns, i.e., without a synergy. The uncontrolled manifold (UCM) hypothesis separates variability into two components, within the UCM (good variability) and orthogonal to it manifold (bad variability). Having more variability in the good category allows the system to be more flexible. However, variability within UCM is not associated with an improvement in accuracy of task performance. Such an improvement could follow from an increase in the number of effectors, due to the dependence between force and its standard deviation.

Prediction of Muscle Forces to Control Musculoskeletal System of Hand with Interaction Among Fingers

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As the control technology of machines and robots that is necessary for many industrial fields have reached a very high level, it is indispensable to develop biomechanical models of the human fingers and hands and apply those models to the design of high-technology devices. Though the biomechanical model of fingers has been studied since 1970s, the number of the fingers involved in the model was small and in addition, the interactions among fingers such as the enslaving effect and the force deficit effect during multi-finger force-production tasks was not considered, which may make the control of fingers more stable has been investigated. In this study,

a three-dimensional biomechanical model of four fingers including three joints in each finger and the muscles was developed. A mathematical relationship between neural commands and finger forces which represents the enslaving effect and the force deficit effect during the multi-finger force-production tasks was proposed. The external forces acting on the end of four fingers respectively could be calculated from that formulation while four fingers push a plate at the same time. The muscle forces and the joint forces were predicted by the optimization technique and the equilibrium equations of muscle forces, joint forces, external forces, and moments derived from those forces around a joint. When fully pressing a plate under the flexed posture, the results showed that the mainly activated muscles as well as the magnitudes of the muscle forces and the joint forces in this study agreed with those in the previous two-dimensional models of one finger. However, there was a meaningful difference in the present model: it was found that the antagonistic muscles were also activated rather than the other models in order to satisfy the equilibrium state, which is a more realistic phenomenon. This might be possible since more muscles were included in the present model. Moreover, since the developed model has considered the interaction among fingers, this model can be more powerful while developing a robot hand that can totally control the multiple fingers as in humans. Also, the present study could be useful to rehabilitate patients with nervous system problems and to design an interface between the control command and the movement of the robot.

Formulation of Pedaling Inverse Dynamics as a Differential Algebraic Equations Problem

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Comprehension and modeling of pedaling biomechanics and control is important for several reasons. It could lead to developing training strategies that enhance performance and avoid overuse injuries in professional cyclists, as well as improve stationary ergometer techniques in physical therapy. The knowledge of net joint muscle torque patterns during a cycle of pedaling, using measured or estimated kinematics is particularly useful to provide insights into the motor control of dynamic biomechanical systems. This procedure is called inverse dynamic analysis. The traditional inverse dynamic approach is to measure kinematic data and pedal forces to compute internal (horizontal and vertical) forces recursively, from bottom to top. Once horizontal and vertical forces are calculated, they are used to solve the momentum balance equation of each link, in order to determine net joint torques. On the other hand, if thigh, shank, foot, crank and bicycle frame can be regarded as a closed chain mechanism, the forces measured at the pedal become "internal forces" to the system, which performs no work on it. Therefore, it can be stated that measurement of the pedal forces is not strictly necessary to compute a valid set of net joint torques in inverse dynamics analysis of such systems. In the present work, a biomechanical model of pedaling is formulated in the framework of Differential Algebraic Equations (DAE), also known as Descriptor Systems. DAEs are differential equations whose variables are subjected to algebraic constraints. In mechanical systems, the differential equations usually describe the multi-body

dynamics and the algebraic ones describe mechanical constraints, such as joints and closed-loop kinematical equations. Such constraints naturally arise when a multibody system is modeled, with fully Cartesian coordinates. The model was formulated as a bidimensional, 8-bar and 3-DOF linkage with two closed loops and 21 coordinates. The bars represent crank, bicycle frame, thigh, shank and foot for the right and left leg. The coordinates represent horizontal and vertical displacements of center of mass and angular orientation of each moving bar. An inverse dynamic analysis was performed, using ankle angle data taken from the literature as the only kinematic input, which transforms the system into a 1-DOF mechanism. The calculated set of joint moments in the hip, knee and ankle were able to successfully reproduce the imposed kinematics, suggesting that the method provides a mechanically consistent solution to the inverse dynamics problem, without measuring pedal forces.

Center of Rotation During Head Movements—A Comparison of Patients with Neck Pain and Healthy Controls

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Introduction: If some of the vertebral joints of the cervical spine do not function properly (from pain or physical injuries) the neck movement kinematics will be affected. One way to evaluate this is by looking at the global axis of motion (Winters et al., 1993; Woltring, 1990). The first aim of this study was to measure the center of rotation (CoR) within a group of patients with neck pain and a group of healthy controls. The second aim was to evaluate if pain intensity influences CoR. *Materials and Methods*: The neck pain group (NP) consisted of 43 subjects (32 females, 12 males), mean age 49 (SD 15) years, with pain lasting longer than three months (Table 1). Their symptoms were muscular without paraesthesia according to clinical assessment. The control group (CON) consisted of 24 subjects (16 females, 8 males), mean age 50 (SD 18) years, without head, neck or back pain. Informed consent was obtained from each subject, and the local ethics committee of Umeå University approved the study.
Movements were registered with a ProReflex system (Qualisys Medical, Gothenburg, Sweden), consisting of retro-reflective markers and five cameras. The coordinate

Table 1 Reported pain intensity in neck and shoulder (VAS scale)

VAS	CON	NP
Neck	0.6 (2.1)	57.9 (21.4)
Shoulder	4.4 (7.7)	50.0 (24.8)

data were filtered with a low-pass Butterworth filter (2nd order) using a cut-off frequency at 6 Hz. In total, 20 head movements were performed: rotation to the side (30 degrees right or left), flexion and extension 25 degrees. A marker was placed on the suprasternal notch and COR was calculated relative to this marker using a finite helical axis model (Soderkvist & Wedin, 1993). *Statistics*: Group differences were tested with an unpaired *t*-test. Correlations were tested using Pearson's correlation coefficient. *Results and Discussion*: The COR was positioned more superior in the CON group relative to the suprasternal notch during flexion: 14.1 (2.0) cm compared to 12.9 (2.0) cm, $p = 0.03$. Also, significant negative correlations were found between the vertical position of COR during flexion with VAS indices for neck (-0.3) and shoulder (-0.4). These findings might indicate that impairments are mainly located in the upper parts of the cervical spine. CoR was also more posterior during rotation to the side: -4.2 (1.6) cm compared to -3.2 (1.7) cm, which might indicate a change in curvature of the cervical spine.

Influence of the Ankle Functional Instability in Coactivation and Onset Timing of Ankle Muscles During Landing After Volleyball Blocking

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Aims: Verify the influence of functional ankle instability (FI) in the onset latencies of ankle muscles after the blocking maneuver and in the coactivation between agonist and antagonist ankle muscles. *Methods*: EMG were acquired from peroneus longus (PL), tibialis anterior (TA) and gastrocnemius lateralis (GL) muscles in 21 athletes with FI and in 20 controls (21 (4) years old) while landing after performing a blocking maneuver. Electrodes were placed on the muscle belly, far away from the innervation zone. EMG were acquired at 1000 Hz and were analyzed during the 200 ms prior to landing (pre landing period) to the first 200 ms following impact (post landing period), determined by the vertical ground reaction force acquired synchronically. Coactivation index (CO) was calculated for pre and post landing periods as, where minutes is the lower signal, and A and B correspond to the full-wave rectified, low-pass filtered, normalized by subject's maximal voluntary isometric contraction and integrated signal of the corresponding period. The CO index was calculated for both periods between: 1) TA and FL; 2) TA and GL. Onset determination was done using the full-waved rectified and continually integrated signal according to the method of Santello and McDonagh (1998). CO index and onset values were compared between groups using *t*-test. Each muscle onset value was compared using ANOVA followed by Scheffé test within each group ($\alpha = 0.05$). *Results*: CO index showed no significant differences between groups neither for pre landing nor for post landing period. GL showed later onset occurrence for FIG prior to landing (CG = 102.3 ± 27.0 ms; FIG = 83.4 ± 35.8 ms, $p = 0.036$), but not for TA (CG = 70.5 ± 50.1 ms; FIG = 51.7 ± 58.1 ms, $p = 0.142$) or PL (CG = 111.4 ± 52.2 ms; FIG = 91.4 ± 25.6 ms, $p = 0.073$). This later onset occurrence for GL diminishes its pre landing activity. Functionally preactivation is necessary to stiffen the joints before mechanical loading. There were differences for the three muscles onset values within the CG ($p = 0.017$) but not within the FIG ($p = 0.570$). In CG, PL and GL activated earlier and TA activated significantly after PL ($p = 0.024$),

a pattern similar to other studies. FIG did not show differences among muscles onset. This fact could explain the existence of instability complaints in FIG. PL is a potentially critical muscle in preventing ankle sprains injuries as a protective mechanism to balance inversion at the impact moment; prior activation of PL to TA is important to prevent an inversion ankle sprain since the PL everts the ankle and acts as an antagonist to TA.

Basketball Jump Shooting Coordination: Comparison Between Men and Women

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Expert male basketball players are widely recognized to have greater efficacy in jump shooting in comparison with their female counterparts. Because efficacy is the result of the pattern of coordination, different coordination of patterns should be found in the comparison between genders. This study aimed to compare movement coordination in basketball jump shooting between skilful male and female players. Five males, mean age 24.2 years (SD = 7.2), and five females, mean age 24 years (SD = 4.2), participated in the study. Their average time of experience in basketball were 10.1 years (SD = 6.9), and 9.8 years (SD = 3.3), respectively for males and females. Arm movements of these two groups were analyzed while they performed basketball jump shooting from the free-throw position. The jump shooting was analyzed only in the sagittal plane. A single camera was set at 4.6 m from the participant position, with frequency acquisition of 60 Hz. A biomechanical model provided the relative angle of the shoulder, elbow, and wrist joints. Images were digitalized through the Dgeeme movement analysis software. A fourth order Butterworth filter with a cutoff frequency of 10 Hz was used to attenuate noise in the signal. Data was normalized in function of the movement time (100%) through a spline function. Confidence intervals of 95% were used to perform the comparisons between genders for angular displacement and velocity. The results showed that women performed their movements with predominant synchronization between the shoulder flexion, elbow extension, and wrist flexion. Women also showed greater angular velocity at the shoulder when releasing the ball. Thus, women seemed to emphasize the generation of impulse to launch the ball. Men, on the other hand, used the strategy of constraining the motion of the shoulder, and performed a counter-movement in the elbow joint to optimize the release propulsion. As movement around the proximal joint (shoulder) would increase distal variability, and there is an inverse relationship between speed and accuracy, this strategy adopted by men seemed to be more appropriate to control accuracy in comparison with women. Therefore, these results show that there are particular movement coordination for expert male and female basketball players. These differences between genders may explain the greater efficacy usually found in basketball shots performed by male players.

Temporal Organization of Arm Movements in Basketball Shooting

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Open kinematic loop movements are usually featured by a proximal-to-distal sequence in high ballistic actions. Due to its mechanical efficiency, this movement organization might be potentially useful also for accurate movements. If so, expert performers on tasks requiring speed and accuracy should select this mode of movement organization. This issue was investigated in the shooting of a basketball. Fourteen males, mean age of 23 years (SD = 4.8), with average time of experience equal to 10.2 years (SD = 4.5) in basketball were analyzed while performing the basketball shooting. Movements were analyzed in the sagittal plane, with a sample frequency of 60 Hz. The analysis was conducted on the relative angle of the shoulder, elbow, and wrist joints. Such an analysis was made using the Dgeeme software. A fourth order Butterworth filter was used to smooth data. Data was normalized as a function of the movement time through a spline function. Relative times from the peak and valley values of angular velocity were used to analyze the sequence of action of the joints. Relative movement time of peak angular acceleration was analyzed at each joint in the main (extension) action component. The results showed that four participants performed the movement with the elbow leading the sequence (57%), followed by the shoulder (78%) and finishing with the wrist (82%). The predominant sequence of joints motion, observed in 10 participants, was elbow extension first (55%), wrist flexion second (76%), and shoulder flexion third (88%). Therefore, none of the participants exhibited a proximal-to-distal sequence. This was explained by two global components, which control the basketball shooting: propelling force and ball's release angle. The propelling component is given by elbow extension and wrist flexion. Force applied at these joints has the role of propelling the ball with a given velocity, which must be finely graded in order to make the ball reach a given distance. Shoulder flexion, on the other hand, is responsible for specifying the release angle. As the propelling force depends on the release angle to make the ball reach the desired position in the shooting, these results suggest that elbow extension-wrist flexion forces are planned in a feedforward mode on the basis of a planed position of the arm given by shoulder displacement. Overall, these results suggest that there are elements of movement control, other than mechanical efficiency, that determine the particular mode of temporal organization in tasks requiring simultaneous speed and accuracy.

The Utilization of Visual Information in the Control of Rapid Interceptive Actions

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Continuous perception-motor models have been widely favored to describe the control mechanisms which underlie all types of interceptive actions. However, different interceptive tasks and types of interception (hitting or catching) may involve distinct control processes. Adopting an alternative version of the operational timing hypothesis developed by Tresilian (2005), we tested the assumptions that for hitting actions with brief movement times, timing control may not be possible post movement onset and therefore that movement parameterization must occur prior to the initiation of action. The aims of the two experiments reported here were twofold. First, we investigated whether in a brief hitting task the preferred mode of control is offline instead of continuous. Second, we sought to verify what types of strategies, if any, are employed to attain the task goal. In experiment 1, eight participants performed brief hitting movements (180 ms duration) towards a moving target under five viewing conditions. Hitting movement was constrained to 1 degree of freedom (1df) via a slide rail. In the control condition the participants had full-vision of the target. In the occlusion conditions, vision of the target was suppressed for 200 ms by liquid-crystal visual occlusion goggles from three different times before the expected movement onset (600, 400, and 200 ms) as well as during movement execution (occlusion began at 0 ms). In the second experiment, eight participants performed their movements under the same viewing conditions used in experiment 1 but this time the hitting movements were constrained to a horizontal plane (2df hitting task). Since directional movements were allowed, a chasing strategy was possible which would effectively increase the time window available in which to hit the target. The results of both experiments showed that performance deteriorated only when the participants had their vision occluded 200 ms prior to movement onset. These results indicate that the remaining time until the target reached the striking zone ($\approx$ 200 ms) was not enough for feedback mechanisms to be effectively employed. The results imply that brief hitting movements were controlled offline by motor programs and that visual information 200 ms prior to movement onset is paramount to trigger the motor program at the correct time.

Long-latency Reflexes of the Upper Limb May Reflect an Internal Model of Limb Dynamics

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While the planar arm model has provided a fertile ground for motor control theories of volitional movement, relatively little is known about reflex coordination in this paradigm. In particular, do upper limb reflexes possess a sophisticated representation of limb mechanics as seen during voluntary movements? Here we examine this issue by recording the surface EMG response of shoulder monoarticulars to torques applied directly at the shoulder and elbow joints (KINARM robot; load range ±2 Nm; 10 subjects). Importantly, we chose perturbations that induced nearly identical displacements at the shoulder joint paired with a range of displacements at the elbow joint. If reflex activity of shoulder monoarticulars solely reflected motion at the spanned/shoulder joint then identical responses would occur across conditions whereas a more sophisticated representation would result in different responses for different amounts of elbow motion. Our paradigm revealed a qualitative shift between early and late reflex periods: short-latency reflexes (25-50 ms) were

influenced solely by shoulder motion and longer-latency reflexes (50-100 ms) were modified by elbow motion. For example, the short-latency reflex of shoulder flexors was only sensitive to shoulder extensor motion whereas the long-latency reflex decreased with increasing elbow flexor motion. The influence of elbow motion on long-latency reflex responses was also observed when we applied a perturbation that induced large elbow motion and minimal shoulder motion; that is, elbow motion was sufficient to elicit or depress long-latency reflexes from shoulder monoarticulars. Although we have presented our results in terms of motion-dependency, the pattern of long-latency reflexes was also appropriate to counter the underlying perturbing torque. The intelligent mapping of motion to torque is evidence that long-latency reflexes include an internal model of arm dynamics.

Recognition of the Physiological Actions of the Triphasic EMG pattern by a Dynamic Recurrent Neural Network

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Triphasic electromyographic (EMG) patterns with a sequence of activity in agonist (AG1), antagonist (ANT) and again in agonist (AG2) muscles are characteristic of ballistic movements. They have been studied in terms of rectangular pulse-width or pulse-height modulation. In order to take into account the complexity of the EMG signal within the bursts, we used a dynamic recurrent neural network (DRNN) for the identification of this pattern in subjects performing fast elbow flexion movements. Biceps and triceps EMGs were fed to all 35 fully-connected hidden units of the DRNN for mapping onto elbow angular acceleration signals. DRNN training was supervised, involving learning rule adaptations of synaptic weights and time constants of each unit. We demonstrated that the DRNN is able to perfectly reproduce the acceleration profile of the ballistic movements. Then we tested the physiological plausibility of all the networks that reached an error level below 0.001 by selectively increasing the amplitude of each burst of the triphasic pattern and evaluating the effects on the simulated accelerating profile. Nineteen percent of these simulations reproduced the physiological action classically attributed to the 3 EMG bursts: AG1 increase showed an increase of the first accelerating pulse, ANT an increase of the braking pulse and AG2 an increase of the clamping pulse. These networks also recognized the physiological function of the time interval between AG1 and ANT, reproducing the linear relationship between time interval and movement amplitude. This task-dynamics recognition has implications for the development of DRNN as diagnostic tools and prosthetic controllers.

Variability of the Co-Contraction Indexes of the Lower Limb in Children with Down Syndrome During the Initial Period of Gait Acquisition

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Objectives: The aims of this study were to evaluate the variability of the co-contraction indexes (ICC) of the hip, knee and ankle joints and a total lower limb index of children with DS during the initial period of gait acquisition. The hypotheses were that the variability of the muscular components, given by the ICC, would decrease during the period of the study, and that the variability coefficient (VC) of the ICC would be different between the three joints. *Methods*: Twelve children with DS were followed during five consecutive assessments: on the week they started independent gait and 15, 30, 60 and 90 days after the first assessment. The ICC of three muscle pairs of the right lower limb, and a total index, were calculated through the quantification of the electric signal of the surface electromyography. A significance level of 0.05 was considered. *Results*: The results showed significant differences for the ankle joint for the assessments between days 0 and 90 (p = 0.047) and between days 15 and 60 (p = 0.004) and days 15 and 90 (p = 0.003). There was also a decrease on the VC of the ankle joint during the stance phase (p = 0.001). There was no significant difference on the hip and knee joints and on the total index on the stance phase as well as no significant differences of the VC were found for any of the joints during the swing phase. *Conclusions*: These results illustrate the importance of the exploration of different neuromuscular mechanisms for the selection and enhancement of more efficient strategies during the acquisition of a new skill.

Influence of Exercise Intensity on Bilateral Pedaling Symmetry

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The bilateral asymmetries during motor tasks have been extensively studied considering the action of upper limbs, task complexity, and limb dominance. For adults, the dominant limb presents advantages in several motor tasks such as writing, throwing, and kicking, regarding force and temporal parameters. During bilateral activities in sports, some studies indicate superior ability of the dominant limb in comparison to the non-dominant, but the effects of exercise intensity have not been fully investigated during cycling. This study investigated pedaling symmetry in response to incremental load during cycling in an attempt to verify the effect of workload on bilateral crank torque asymmetry. Six trained cyclists performed an incremental maximal test on a cycle ergometer SRM® that measured the propulsive crank torque. Based on the cyclist's peak oxygen uptake (VO_{2peak}), four exercise intensity zones were determined (< 50%; 50% to 70%; 70% to 90% and

> 90%VO_{2peak}). A two-way ANOVA was used to compare the crank torque peak between the dominant (kick leg) (DO) and non-dominant (ND) leg for each intensity zone. The crank torque was statistically different among the lower limbs for intensities under 90%VO_{2max}. For intensity below 50%VO_{2max} the right torque and left torque peak were 7.95 ± 0.68 and 7.32 ± 0.25, respectively. For an intensity of 51-70% VO_{2max} the crank torque was 15 ± 0.38 and 14.09 ± 0.53, and at the intensity of 71-90% the crank torques were 21.89 ± 0.48 and 20.79 ± 0.54, both for right and left limbs, respectively. The hypothesis that for the highest intensity zone (> 90% of the VO_{2peak}) crank torque asymmetry is not observed was confirmed. However, at the lower exercise intensities there was evidence of crank torque asymmetry, which was related to lower limb dominance. The symmetry in highest intensities appears to be related to the higher force production in an attempt to support the workload. It is evident from the present study that asymmetry indexes are in direct relationship with lower limb dominance. In this regard, training strategies may be implemented which would serve to curb dominance leading to pedaling symmetry, develop protection mechanism against overload pathologies, and perhaps lead to greater efficacy in performance. The repeatability of kinetic asymmetries during cycling requires further investigation to verify its effect on cycling performance.

Selective Activation of the Rectus Abdominal During Fatiguing Tasks

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Introduction: The rectus abdominis (RA) has been intensely studied particularly because of the potential selective activation of its portions which could possibly be elicited in different abdominal exercises. In a morphologic aspect, the RA is a poligastric muscle with four portions in each left and right sides of the body. A description of the RA muscle innervations has shown that different portions are innervated by different nerves and the same portion can receive more than one nerve innervation. In the present study we investigated the effect of fatigue on the selective activation of the RA during two motor tasks. *Methods*: Ten healthy adult (mean age: 26+/-8 years) performed isometric curl-up and leg-raise exercises. A load cell provided the visual feedback of the force produced by the subjects during each exercise and they were required to maintain a constant force of 50% of their MVIC (maximum voluntary isometric contraction) for 60 s. In conjunction with the force, we recorded the electromyographic (EMG) signal from two portions of the right side of the RA muscle. The MVCI signals were used to normalize the force and EMG data. The EMG and force signal were acquired with 1024 Hz, and band-pass filtered at 40 to 400 Hz with a fourth order Butterworth filter. We analyzed the amplitude and frequency of the EMG signal using a moving-window RMS and a windowed FFT. *Results*: An ANOVA revealed a significant interaction between tasks and portions on the fatigue index obtained from the FFT analysis [$F(1,9) = 10.21$, $p = 0.011$]. Post hoc revealed a higher index of fatigue of the upper portion at the curl-up exercise than during the leg-raise exercise [$t(9) = -2.82$, $p = 0.02$] and a higher index of fatigue of the upper portion than the lower portion during the curl-up exercise [$t(9) = -3.38$, $p = 0.08$]. *Conclusion*: The results suggest differences on muscle portions activation during fatiguing tasks.

Development and Validation of a Biomechanical Instrumentation to Evaluation of Trunk Balance

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From a biomechanical point of view, the trunk is one of the human body's most significant functional units. The deficit in its balance is a common disorder observed in patients admitted to rehabilitation services. There is a shortage of national biomechanical instrumentation technology to evaluate this function. The aim of this research is to develop and validate a biomechanical instrumentation-balance board with contact sensors, to evaluate trunk balance in the sitting position. The stage of research intended for the prototype making is characterized as a technological development, whereas the instrument validation stage as a co-relational descriptive research. The prototype was developed in the Instrumentation Laboratory of the Universidade do Estado de Santa Catarina (UDESC). The data collection for the validation was carried out in the Biomechanics Laboratory (UDESC). The determination of the concurrent validation was made based on the comparison of the data obtained simultaneously on the balance board (prototype) with the data from the displacement of the center of pressure (CoP) of the force plate AMTI (Advanced Mechanical Technology, Newton, MA) OR6-5 Biomechanics; model OR6-5-200. Six tests were elaborated by the researchers with 30 s collection and 60 s interval between tests. Test 1: subject sitting with both feet bare on the floor, the hip and knee flexed at 90º ; Test 2: subject sitting leaning on the lower dominant member, hip and knee flexed at 90º; Test 3: subject sitting leaning on the non-dominant lower member, hip and knee flexed at 90º. Tests 4, 5 and 6 follow the previous tests, however, with the eyes shut. In all the tests the subject remained cross-armed with the hands touching the opposite shoulder. Two sequences of tests were made; in both sequences the results showed a great interclass correlation (Pearson correlation) between both instrumentation data. Sequence 1: Test 1 (0.999); Test 2 (0.973); Test 3 (0.925); Test 4 (0.995); Test 5 (0.967) and Test 6 (0.780). Sequence 2: Test 1 (0.997); Test 2 (0.990); Test 3 (0.973); Test 4 (0.996); Test 5 (0.978) and Test 6 (0.916). Further tests are necessary with a larger number of subjects and patients to broaden the validation of this development prototype. However, the data collected so far point favorably to the aims of this research.

Gait Laboratory Testing: Repeatability of Dynamometric Measurements

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Mounting a gait laboratory requires the evaluation of the measurement techniques employed in order to better understand the motor behavior. The repeatability analysis of ground reaction forces (GRF) is a fundamental stage of this process. Therefore, the purpose of this study was to measure the vertical component (Fz)

of GRF, in order to quantify its repeatability and further to build a representative database of dynamometric measures for gait analysis. These data are important for future comparisons among different groups and functional conditions. Ten adult women (age: 25.0 ± 2.2 years, body mass: 57.9 ± 8.6 Kg and height: 163.8 ± 0.1 cm), without apparent musculoskeletal and neurological disorders volunteered for this study. The Fz of GRF was registered during walking with two force plates (Bertec Corp., model 4060-08), fixed to the floor. The data were sampled with 150 Hz, bandpass filtered with a cut off frequency of 30 Hz and normalized by body mass and stance time. The data acquisition was performed during 1 week, in three different days and in the same conditions. Five valid trials were accomplished in a self-selected speed with the right (RF) and left (LF) feet in order to calculate the symmetry index (SI). The repeatability of maximum (Fz1 and Fz3) and minimum (Fz2) forces were analyzed. Intra and inter-days repeatability were evaluated through intraclass correlation coefficient (ICC). The coefficient of variation (CV) was used to determine the dynamic patterns variability of Fz waveforms. It was observed that the inter-days SI was 1.99% for Fz1, 1.73% for Fz2 and 3.94% for Fz3. The repeatability of the three variables was excellent for intra-days analysis (RF ICC: Fz1 = 0.94; Fz2 = 0.98 and Fz3 = 0.95; LF ICC: Fz1 = 0.98; Fz2 = 0.97 and Fz3 = 0.90) and inter-days (RF ICC: Fz1 = 0.93; Fz2 = 0.97and Fz3 = 0.91; LF ICC: Fz1 = 0.94; Fz2 = 0.96 and Fz3 = 0.94). The CV for Fz was 10.11% for RF and 12.83% for LF. In light of these results, it was verified that the measures are repeatable and symmetric and the variability low. Therefore it is possible to employ this tool for the composition of a locomotion database that could possibly guide clinical comparisons and also improve the understanding of this behavior.

AMPA-type Receptors Distribution at Avian Vestibular Nuclear Complex

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The vestibular complex nuclei of vertebrates receive a large number of multissensorial inputs, mostly primary peripheral afferents from the vestibular apparatus. One of the attributed functions of these nuclei is to process and modulate incoming information through local interconnections prior to sending motor efferent impulses to skeletal and ocular muscles integrating postural visual-motor responses. By this way the body adjusts its posture and balance according to the stimuli received from the ambient condition. The presence of glutamate receptors was detected in that area suggesting an important role of the glutamatergic system in the modulation of postural adjustment. Some bird species like chicks (*Gallus gallus*) can stand, walk, and keep their balance within a few hours after they are born, indicating a quick maturation of the prime motor system related to these functional activities. These characteristics make this species an excellent experimental model to study the developmental and involvement of the vestibular neurochemical system in postural control. We used chicken brains ($n = 5$) to investigate the immunolabel pattern of the subunits GluR2/3 and GluR4 of the AMPA-type glutamate receptors into the dorsal (ndD) and ventral nuclei (nvD) of the Deiter's vestibular complex (CD), the avian correspondent to the mammalian lateral vestibular nucleus. Our results revealed that 80% neurons of the ndD contain predominantly GluR2/3 are rounded, medium and large-sized, mostly located at the lateral portion of the rostral pole and

at the medial portion of the caudal pole. The majority of cells that express GluR4 are large and giant-sized, are also rounded, and their distribution have the opposite pattern of the GluR2/3+ cells with 61% located on the medial portion of the rostral pole and 60% on the lateral potion of the caudal pole. As to the nvD, GluR2/3 and GluR4 were equally expressed with no area or size preference, but most neurons were rounded. This distinct arrangement indicates possible functional differences into and between CDs nuclei, also signaling that such variation could be attributed to diverse subunits compositions at the AMPA-type receptors. Together, our data show new AMPA-related functional subdivisions at each vestibular nucleus indicating that any potential intervention into that system, as experimental or designated to rehabilitate the postural adjustments, should take that into account. (Supported by FAPESP 04/11039-6.)

Study of Myoelectric Activity in Isometric Exercises with Different Contractions

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The aim of the present study is an evaluation of isometric exercises in different ways and levels of force, by the surface electromyography (EMG) parameters. Two forms of isometric exercises were studied: dissipative and conservative. The first one was obtained by the traction of a steel cable fastened to the system, being maintained in such a way to provide 90º of flexing of the elbow; in the other one, the resistance was applied through weights, whose value is equal to the load developed previously. In both situations the forearm was maintained in supine position and the load was controlled by visual feedback. Twenty young male volunteers participated in this study which was approved by the local ethics committee. Half of those carried out isometric actions with 100% maximal voluntary contraction (MVC); and the others carried out with 10% and 50% MVC. All the isometric exercises were done in 10 repetitions of 3 s each—both dissipative and conservative types, in random order for execution. Surface EMG was detected from biceps brachial, long and lateral triceps brachial. For signal processing, Matlab (version 6.1) was used, applying a Butterworth digital filter of the fourth order (bandwidth = 10-500 Hz). The root mean square (RMS) was analyzed in time domain as well the power spectral density (PSD) and the spectral distribution function (SDF) in the frequency domain. The analysis of the differences between the exercises, for which level of force, was carried out by use of Student's t-test. Visualization techniques were also used in analyses. The parameters of EMG signal showed differences between dissipative and conservative exercises depending on the level of force applied. The differences increased while higher levels of force were used for the three muscles, mainly in 100% MVC. The results showed in this work permit us to infer that the dissipative have larger muscular activation and bigger activation of slow twitch fibers; whereas in the conservative there are smaller muscular activation and larger activation of fast twitch fibers. Additionally, these results can be important to those who use isometric

protocols. We believe that in clinical rehabilitation, when the objective is increasing the muscular force, the activity developed with dissipative exercise can present better results than the conservative. Otherwise, when the objective is improving motor control or muscular coordination, the activity developed with conservative exercise can present more interesting results compared with dissipative.

Scapular Muscle Activity During Lowering of the Arms

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Several studies have investigated and described scapular muscular activity during elevation of the arms in the scapular plane and demonstrated the importance of a coordinated and synchronized action of these muscles during all of the range of motion of the shoulder joint. However, no studies were found regarding the electromyographic (EMG) activity of the scapular stabilizer muscles during lowering of the arms. Individuals with shoulder impairments often describe lowering of the arms to be more painful than their raising and clinical observations have shown significant alterations of scapular kinematics in these subjects during this movement. For a better understanding of these alterations, complaints, and about shoulder pathology associated with muscular impairment, the first step is a detailed description of the muscular activity in healthy subjects. Therefore, the aim of this study was to describe the EMG activity of the serratus anterior, upper, middle, and lower trapezius muscles during lowering of the arms, considering six different phases of the movement on the dominant and non-dominant sides. Ten healthy subjects performed the movement of lowering the arms immediately after their elevation. EMG was quantified and normalized for six different phases: from full elevation to 150° (Phase 1); 150° to 120° (Phase 2); 120° to 90° (Phase 3); 90° to 60° (Phase 4); 60° to 30° (Phase 5); and 30° to the end of the movement (Phase 6). Repeated measures ANOVAs followed by pre-planned contrasts were used to investigate main and interaction effects between sides/phases ($p < 0.05$). All muscles showed a tendency of lowered EMG from the beginning to the end of the movement, and significant differences between phases were found (6.19)

Analysis of Forces During Isometric Movement of the Deltoid Muscle: Electromyographic Study

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During the rehabilitation of shoulder impingement syndrome, the individuals present a considerable decrease in force of abduction and external rotation in the injured shoulder, when compared to the healthy limb. These individuals relate pain during the abduction movements and external rotation, possibly caused by the decrease in muscular force. This study is aimed at comparing electromyographic activity of the anterior, middle and posterior portions of the deltoid muscle, as well as the force exerted during abduction, in healthy individuals and in those with shoulder

impingement. Fifteen subjects with impingement syndrome (44.1 ± 8.6 years old) with Neer degrees I and II took part in the study; fifteen healthy subjects (43.6 ± 8.1 years old) were paired to those of the first group. Electromyographic signals were collected in static voluntary contraction during traction of a force transducer, while the shoulder remained at 80° abduction, and normalized according to the maximum reference isometric contraction. Mann Whitney's parametric test was used at a significance level of $p < 0.05$ to compare electromyographic (RMS values) of the deltoid muscle pairs, as well as the force between the two groups. There were no significant differences in electromyographic activity and the force measured in the force transducer between the healthy control group and the impingement syndrome group during the upper limb 80º abduction, in the scapular plane of static voluntary contraction. The study concluded that there was no difference in electromyographic activity of the deltoid muscle or in the force exerted during abduction of the upper limb between healthy controls and individuals with shoulder impingement. It may thus be suggested that deltoid muscle strengthening should not be the main focus during the rehabilitation process.

Handwriting Control: A Kinetic Perspective

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Handwriting is one of the most fundamental forms of communication. Its production is unique to each individual and yet its result is universally recognizable. Numerous studies involving handwriting kinematics to both generate movement models as well as to quantify the effects of many neural disorders have been conducted. These studies were limited to the trajectory of the pen on the paper due to instrumentation limitations in measuring accurate kinetics. The purpose of this study was to investigate force and moment synergistic relationships between the varying contact points of the writing utensil and the hand through the development of a novel utensil. The purpose of this study was to investigate force and moment synergistic relationships This "super pen" contains four, six-component sensors countersunk into the pen's body. Each sensor is equipped with a moment arm running along the long axis of the pen such that its only contact point with the body of the pen is at its attachment point on the sensor. At the writing end of the pen, each moment arm has a rounded grip pad with each pad corresponding to a single, unique contact point with the hand. The four points making contact with the pen were the tip of the thumb, the tip of the index finger, the lateral surface of the middle finger's distal phalanx, and the webbing between the metacarpophalangeal (MCP) joints of the thumb and index finger. The moment arms were very rigid and did not bend under forces attainable in normal handwriting. Because each moment arm had only two contact points, one at the sensor and one at the sensor's respective digit, the reading detected by the sensors could be transformed to represent the forces and moments of each contact point, individually, at its respective grip site. Subjects with no previous history of neural disorders performed a series of basic line and shape writing tasks of varying speeds and sizes with a six-component force plate as a writing surface. The normal and tangential forces and free moment about the normal axis

were analyzed for each contact point and condition. The results showed force and moment synergies between the grip sites, indicating that the central nervous system controls the peripheral structures involved in writing as a unit. The ability of this tool to quantify handwriting in an unprecedented manner will allow us to better understand both the generation of handwriting control of the general population as well as the special population of neurosis patients.

Biomechanical Analysis of Mouth's Orbicular Muscle in Individuals Classe Ii: Study Electromyographics

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Bucal respiration is believed to bring serious effects in craniofacial development and occlusion, when there is no correlation among the internal and external forces of bucal musculature. This way, for a precocious diagnosis and the formulation of a suitable treatment plan it is fundamental to know whether the individual's peribucal musculature has suffered ambiental influences, to the point of altering its physiology. This electromyographic study's purpose was to compare the medial superior region of the mouth's orbicular muscle in two groups: G1 (predominantly nasal respiratory pattern) and G2 (predominantly bucal respiratory pattern). Fifty Brazilian children from 6 to 9 years old were evaluated, 25 boys and 25 girls with Angle's Class II division 1 malocclusion. The EMG activity was captured by an EMG System do Brasil Ltda composed of differential double electrode, a bandpass filter at 20 to 1000 Hz, and a subsequent amplification of 50 times with a common mode rejection ratio of 120 dB. The data was sent to a 14-bit A/D converter and sampled at 2,000 Hz. A differential double electrode was used, with pre-amplification with 100 times pre-amplification, 25 mm^2 contact area and contacts 10 mm apart. Sampling frequency was 2,000 Hz. The electrodes were placed bilaterally over the orbicular muscle of the mouth. All applicable recommendations from the International Society of Electrophysiology and Kinesiology (ISEK) regarding electromyography applications were followed in all EMG signal procedures. Signal handling consisted of full wave rectification, linear envelope through a fourth order Butterworth filter, with 5 Hz cut off frequency, normalized in time base and amplitude, this one through average value. EMG signal intensity variability was calculated through the variability coefficient (VC). The comparison between the EMG signals from the various muscles was made with the *t*-test, with a significance level of 0.05. Variations of around 20% were found among samples during the pronunciation of letters A and F, not found at rest. Other new observations to confirm these findings should be performed, especially with older children, to detect the time frame in which a differentiation occurs (the time frame in which, for instance, the bucal habits are installed, and the time frame in which orthodontists or phono must interfere), resulting in labial incompetence. A deep knowledge of muscular dynamics provides the basis for correct therapy. In this context, electromyography becomes a vast exploration field, with valuable contributions not only to orthodonty, but also to physiotherapy and phonoaudiology.

Trunk Antagonist Co-Activation is Associated with Impaired Neuromuscular Performance

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Aims: The goal of this paper was to determine if trunk antagonist activation is related to impaired neuromuscular performance. To test this hypothesis, we used two methods to degrade neuromuscular control: strenuous exertions and fatigue. *Methods*: Force variability (standard deviation of force signal) was assessed for graded isometric trunk exertions (10, 20, 40, 60, 80% max) in flexion and extension, and at the start and end of a trunk extension fatiguing trial. Normalized EMG signals for five trunk muscle pairs (RA – rectus abdominis, EO – external oblique, IO – internal oblique, TE – thoracic erector spinae, and LE – lumbar erector spinae) were collected for each graded exertion and during the fatiguing trial. *Results*: Force variability increased for more strenuous exertions in both flexion ($p < 0.001$) and extension ($p < 0.001$), and after extensor fatigue ($p < 0.014$). In the flexion direction, all antagonist muscles (TE, LE) increased activation for more strenuous exertions. In the extension direction, all antagonist muscles except RA increased activation for more strenuous exertions ($p < 0.001$) and following fatigue ($p < 0.01$). *Conclusions*: There appears to be an association between force variability and antagonist activation, which we believe is related to the quality of neuromuscular control and the requirement for maintaining spine stability. Perhaps the CNS responds to the destabilizing nature of internal disturbances through selective recruitment of those muscles that best maintain stability. RA, spanning the entire lumbar spine, may not fit this criterion. If it is true that degraded neuromuscular control results in increased antagonist activity, then any scenario in which neuromuscular control is compromised (i.e., fatigue, prolong trunk flexion, etc.) will most likely increase spinal loading and possibly risk of injury.

Comparisons of Electromyographic Activity of the Scapular Muscles Between Subjects With and Without Shoulder Impingement Syndrome

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Clinical observations and studies have shown important differences between elevation and lowering of the arms and significant changes in scapular kinematics during lowering of the arms in individuals with shoulder impingement syndrome (IS). However, studies regarding the scapular muscles during lowering of the arms are lacking. Furthermore, studies about the electromyographic (EMG) activities of the scapular stabilizing muscles did not investigate their actions in synergic pairs, which are essential to allow efficient coordination of movements. Therefore, the aims of this study were to compare the amount of isolated EMG activity of the serratus anterior, upper, middle, and lower trapezius muscles, as well as the amount of EMG co-activation of the synergic pairs, upper trapezius/serratus anterior and middle trapezius/serratus anterior, during the lowering of the arms of individuals with IS. Lowering of the arms was performed immediately after elevation in the scapular

plane. Twenty young adults participated, 10 with unilateral IS degree I or II (29 ± 5.4 years), with a mean duration since onset of the symptoms of 2.8 ± 1.6 months, and 10 without any complaints or history of previous shoulder lesions (28.6 ± 5.9 years), matched by gender, age, and levels of physical activity. The EMG activity of each muscle was quantified by root mean squares, which were normalized by maximal voluntary isometric contractions (MVIC), whereas co-activation for each pair of muscles was quantified by the common area of the EMG activity curve. Mixed ANOVAs were used to investigate main and interaction effects between groups and sides for all variables ($\alpha < 0.05$). No significant differences between groups were found in the mean range, duration time, and movement velocity ($p > 0.35$). No significant differences were found between groups ($0.01 < F < 3.11$; $10 < p < 0.91$), sides ($0.31 < F < 0.75$; $0.31 < p < 0.75$), nor any significant interactions between groups and sides ($0.02 < F < 0.97$; $0.34 < p < 0.88$) for all variables related to isolated EMG activity. Of all investigated variables, significant differences between groups were found only for the co-activation of the synergic pair between the middle trapezius/serratus anterior during the complete movement ($F = 6.81$; $p = 0.02$) and its sub-phases ($F = 4.78$; $p = 0.04$). There were no effects of side ($F = 0.05$; $p = 0.83$), nor significant interactions between groups and sides ($F = 3.85$; $p = 0.07$). In conclusion, the synergisms of the scapular muscles during lowering of the arms, specifically between the middle trapezius and serratus anterior, muscles that are responsible for maintaining the scapula against the thorax, appear to be important aspects to be considered in studies on motor behavior of these muscles in subjects with IS.

Influence of Four Different Modalities of Active Hip Extension on Muscular Recruitment Patterns

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Studies suggest that low back disorders are associated with muscular imbalance and, currently, emphasis has been placed on the importance of achieving coordinated activity between all muscles within a balanced system for the prevention and treatment of low back pain. Changes in activation patterns of hip extensors and pelvic stabilizing muscles are recognized as factors that cause low back disorders. Therefore, the aim of this study was to investigate muscular recruitment patterns of the gluteus maximus, semitendinosus and erector spinae muscles with healthy young individuals during four different modalities of therapeutic exercises. Thirty-one volunteers were selected: (16 men and 15 women), aged 24.5 ± 3.47 years, a body mass of 66.89 ± 11.89 kg and a height of 1.70 ± 0.09 m. They performed three randomly assigned trials of the four modalities of therapeutic exercises in the prone position often used in clinical practice: with knee extension (KE), knee flexion (KF), lateral hip rotation and knee extension (LHR-KE), lateral hip rotation and knee flexion (LHR-KF). The electromyographic (EMG) activity of the gluteus maximus, semitendinosus and erector spinae muscles was recorded to determine muscle pattern activation for each exercise. The mean of the three trials for each exercise was used for analysis. The beginning of the movement was determined by changes in angular displacement of the rigid segments obtained from the motion

capture system. A trigger was employed for synchronizing the EMG activity and the motion capture system data, after assuring EMG silence. Repeated measure ANOVAs followed by planned contrasts were used to investigate differences in recruitment patterns for the four modalities of exercise ($\alpha < 0.05$). The analyses revealed that muscle activation patterns were similar for the four analyzed exercises, starting with the semitendinosus, followed by the erector spinae, and then the gluteus maximus. The gluteus maximus was the last activated muscle during hip extension associated with KF ($p < 0.0001$), KE ($p < 0.0001$), and with LHR-KF ($p < 0.05$). In conclusion, the present findings indicated that despite individual variability, the order of muscle firing was similar for all four exercise modalities, initiated by the semitendinosus and followed by the lumbar erector spinae and gluteus maximus. The gluteus maximus was the last muscle activated for the exercises performed with KE, KF, and LHR-KE.

Female Workers with Subacromial Impingement Syndrome Do Not Present Shoulder Proprioceptive Deficits

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Background: Proprioceptive deficits can generate large deficits in muscle recruitment patterns, resulting in dysfunctions in several conditions. Shoulder proprioception may be more impaired in situations of large demands on the joint structures, as it occurs in stage III of subacromial impingement syndrome. Then, the evaluation of proprioception in subjects with subacromial impingement syndrome may help to further elucidate if neuromuscular control is impaired in these subjects. *Objective*: To evaluate joint position sense during medial and lateral rotation in female workers with shoulder impingement syndrome. *Subjects*: Forty-five women were evaluated and divided into three groups: experimental group (EG) composed of 15 female workers in the school supply industry (35.5 ± 5.8 years) with Neer's stages I and II unilateral shoulder impingement syndrome; healthy workers group (WG) composed of 15 female workers in the same industry (34.7 ± 4.8 years) with no shoulder dysfunction; and healthy group (HG) composed of 15 healthy female non-workers (33.1 ± 6.2 years) with no shoulder dysfunction. All volunteers gave their written and informed consent agreement to participate in this study which was conducted according to the Helsinki Statement. *Methods*: Proprioception was evaluated by measuring the joint position sense bilaterally during isokinetic concentric medial and lateral rotation. Passive and active repositioning were performed at 2º/s and 5º/s, respectively, for two target angles in the scapular plane: 45º of internal rotation (from 90º of abduction and lateral rotation) and 75º of lateral rotation (from 90º of abduction and neutral position of rotation). The target angles were shown passively and the subject had 10 s to concentrate in each target angle for passive and active repositioning. They performed three repetitions for each target angle with 1 min of rest between them. The results were analyzed by the absolute error medium. *Analysis*: A two-way ANOVA and Duncan post-hoc tests were used for statistical analyses between groups for involved (EG) and dominant (WG and HG) shoulders. A level of 5% was used to determine significant differences. *Results*: No significant difference ($p > 0.05$) was found between groups for passive and active

repositioning results. *Conclusion*: No proprioceptive deficit in female workers with and without shoulder impingement syndrome was found when they were compared with healthy women. Thus, we can suggest that in early stages of this syndrome, the maintenance of the physical activity with upper extremities can be a factor of negative influence on the early sensorial diagnoses of this syndrome.

Theories and Methods

An Alternative Method of Muscle Force Analysis Based on the Mechanomyographic Signal

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The electromyographic (EMG) signal is one of the most popular methods used in muscle contraction studies. Recently some authors have also regarded the interaction of muscular mechanical properties with the myoelectric activity by a method called mechanomyography (MMG). In this context, the MMG signal has been considered a complementary method to the EMG analysis, potentially helpful to better explain the phenomena concerning muscular contraction. The MMG signal seems to reflect dimensional changes of muscle fibers, which may be propagated as mechanical waves through the tissues from the muscle fibers to the skin surface, being able to be collected by different transducers. When using accelerometers, most authors suggest that the main information related to motor units strategies is contained in the perpendicular direction (X axis) to the muscle fibers. Despite this, a few authors have also verified a longitudinal acceleration (Y axis). Thus, this study aimed at evaluating the relation between muscle force and MMG signal neither in X and nor in Y direction alone, but through a so-called resultant acceleration. Twenty-five volunteers (15 men and 10 women) were instructed to perform non-fatigued isometric contractions at five percentile levels of their maximum load (%ML), varying from 20% to 100% of ML. A biaxial accelerometer and a dynamometer system were used for collecting the MMG and force signals. All the volunteers received visual feedback through a video screen for reaching the target force levels without overshooting. The root-mean square (RMS) values of the MMG signals (RMS X and RMS Y) were then calculated for the two axes defined by the accelerometer. From such RMS values the magnitude (RMS R) and phase (Phase R) of the resultant acceleration were calculated. The Pearson linear coefficient (alpha = 0.05) was calculated between each percentage of ML and the RMS X, RMS Y and RMS R values. All three parameters were statistically significant ($p < 0.05$) correlated to the %ML only up to 60% of ML. Higher levels (80% and 100% of ML) did not present significant correlation. The RMS R obtained higher values for Pearson's coefficients than RMS X or RMS Y, but Phase R was not statistically correlated to %ML. The results suggest that both X and Y directions seem to reflect mechanical components of muscle fibers vibration and that the state of fusion of

the muscular fibers influences in a nonlinear way the relation between acceleration and force at higher levels of muscular contraction.

Comparison Between Dominant and Non-Dominant Arms Based on the MMG Signal

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It is well accepted that physiological and mechanical properties of skeletal muscle alter with daily preferential use. Traditionally, motor unit properties have been investigated by means of the electromyographic (EMG) signal, with the aim of elucidating which strategies could be better associated with handedness. This study intended to compare dominant and non-dominant arms based on the mechanomyographic (MMG) signal. The rationale of using the MMG signal as an alternative method to investigate muscle activity is supported by the fact that each motor unit action potential (MUAP), when it reaches its muscle fibers, produces some mechanical oscillations related to the developed tension (usually defined as muscle twitch). A muscle twitch represents dimensional changes that occur either on the transverse or longitudinal axis. Thirty-nine healthy volunteers, divided into two groups: 19 males (mean age 25.3 ± 8.1 years), and 20 females (mean age 20.6 ± 2.6 years) performed unfatigued isometric contractions at five different intensities (including 100% of maximal voluntary contraction (MVC): 20%, 40%, 60%, and 80% of MVC) while MMG signals were collected from dominant and non-dominant biceps brachii muscles through an accelerometer. During the tests the subject had visual feedback through a target line shown on a video screen, related to the degree of force that he had to maintain and was instructed to track the force target line with a minimum of overshooting. The mean frequency (MF) and the RMS value were calculated from the MMG signals coming from lateral oscillations of muscle fibers. RMS values increased with the contraction level, but with differences between genders. MF values decreased with the increase of muscle contraction. Both parameters were not consistent on pointing out any difference between the dominant and non-dominant arms. The results suggest that the summation of muscle twitches, measured by means of two features computed from MMG signals collected using accelerometers, seem not to reveal any difference of biceps brachii muscle between dominant and non-dominant arm during isometric contractions. To our knowledge, this is the first study that compares the MMG signal between both arms. It is well known that within the same muscle the motor unit recruitment and frequency pattern strategies vary depending on the motor task requested and whether the muscle is acting as agonist or antagonist. Thus, we suggest that different muscles performing similar tasks must be also considered for analysis through the MMG signal.

The Effect of Nature of Precued Parameters on Reaction Time of a Force-Production Task

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Results of previous studies on parameter precuing technique suggested a relationship between reaction time (RT) and number and nature of precued parameters. Most of these studies only examined aiming movements as the experimental tasks. The present study was designed in order to test the effect of nature of precued parameters on RT in a force production task. A mixed three factorial design was performed on non-athlete right-handed volunteer students (n = 16; age = 20 to 25 years). Having applied a ''parameter precuing apparatus,'' subjects performed 2,400 trials over five sessions on successive days (four blocks of 120 trials per session) under different precued conditions of precuing. The task required production of defined isometric force (3 or 6 kg) toward inside or outside, with right or left upper limb as quickly and accurately as possible after displaying the stimulus preceded by the precue. The subjects' RT in different levels of independent variable were analyzed by using three factor experiments (nature of precued parameter × gender × session) with repeated measures on two of the factors (type of precued parameter and session). It was found that the main effects of nature of precued parameter and session were significant ($p < 0.05$); but the main effect of gender, interaction of nature of precued parameter and gender, and gender and session were not significant ($p > 0.05$). The results are discussed in relation to their significance in the context of current theories and hypotheses on movement programming.

The Effect of Number of Precued Parameters Independent of Number of Stimulus-Response Alternative on Reaction Time of a Force Production Task

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Precue is one of the effective factors on RT. The results of studies done on this factor have shown the reduction of RT as function of amount of precue information; but the amount of effect of number of precued parameters independent of stimulus-response alternatives has not been defined exactly. The present research was performed in order to test the hypothesis that RT in a force production task is function of number of precued parameters. A mixed three factional design was performed on 16 (8 male and 8 female) volunteer, non-athletes, right-handed students ranging in age from 20 to 25 years. Using a ''parameter precueing apparatus,'' subjects performed a total of 2,400 trials over five sessions on successive days (four blocks of 120 trials blocks per session) under different 2-choice conditions with 1 or 2 precues. The task required production of defined isometric force (3 or 6 kg) to inside or outside, with right or left upper limb as quickly and accurately as possible after displaying precue followed by stimulus. The subjects' RT in different levels of independent variable were analyzed by using a three factor design (number of precued parameters × gender × session) with repeated measures on two of the factors (number of precued parameters and session). The results indicated that RT was not a function of number of precued parameters in this task ($p > 0.05$). The main effect of gender

and interaction of number of precued parameters and gender were not significant ($p > 0.05$); but the main effect of session was significant ($p < 0.05$).

The Effects of Degree of Overlap of Muscle Neuronal Representations in the Cortex on Reaction Time

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Motor programming process is one of the issues that has not been defined exactly yet and still there exist more questions regarding it. The results of studies done by the parameter precuing technique have shown the relationship between reaction time (RT) and number and nature of precued parameters, but there exists some differing explanations as to the cause of the effect of different precued parameters on RT. The present research was performed in order to test the hypothesis that RT is a function of degree of the overlap of muscle neuronal representations in motor cortex of brain. A mixed three factional design was performed on 16 (8 male and 8 female) volunteer, non-athletes, right-handed students ranging in age from 20 to 25 years. Using a ''parameter precueing apparatus,'' subjects performed a total of 2,400 trials over five sessions on successive days (four blocks of 120 trials blocks per session) under different conditions of precueing. The task required production of defined isometric force (3 or 6 kg) toward inside or outside, with right or left upper limb as quickly and accurately as possible after displaying precue followed by stimulus. The subjects' RT in different levels of independent variable were analyzed by using a three factor design (degree of overlap × gender × session) with repeated measures on two of the factors (degree of overlap and session). The results indicated that RT in this task was a function of degree of overlap of muscle representations in the motor cortex ($p < 0.05$). These results are consistent with the cortical cell assembly theory of motor programming (Wickens, et al., 1994). The effect of gender on RT was not significant ($p > 0.05$); but interaction of degree of overlap and gender, and main effect of session was not significant ($p < 0.05$).

The Linear Co-Variance Between Dynamic Torques Is Not a Generalized Principle

Luciane Sande and Gil Almeida

The principle of linear covariance is used to characterize the linear synergy between elbow and shoulder dynamic muscle torques during the performance of pointing movements with or without reversal. The first aim of this study was to show that indeed there is some region of the workspace in which both joints moved out of phase violating the principle of linear synergy. The sum of dynamic muscle torque and interaction torque define the net torque. Thus, the second aim of this study was to test the hypothesis that for movements in which the principle of linear covariance is broken, the net torque between both joints would be linearly correlated. Neurologically healthy subjects performed multijoint movements with reversal over three targets, without any mechanical constraining, in the regions of the workspace that elbow joint moved out of phase with the shoulder joint. Even though the fingertip pathways were characteristic of straight line reported for pointing movements, the

elbow and shoulder joint torques did not co-vary linearly. However, net torques at both joints were linearly correlated. The results showed that the strategies available to the CNS to perform multijoint movements are more abundant than previously described by the principle of linear co-variance. Because the net torque is a direct function of the linear acceleration of the limb, to reduce the number of controlled variables, the CNS just needs to couple the linear accelerations of both limb segments.

Multijoint Movements with a Reversal in Parkinson's Disease

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Kinematic, kinetic and electromyography behavior during multijoint reversal movements in Parkinson's disease (PD) was assessed. Nineteen volunteers (9 healthy and 10 Parkinsonians) participated. With their elbow and shoulder, they performed rapid multijoint movements with reversal, to and from three targets (D1-D3). The elbow angle was kept at 45º from full extension and the shoulder moved 30º in D1, 60º in D2 and 90º in D3. Angular joints excursion were recorded by a movement analysis system (OPTOTRAK 3020). Electrical activity (EMG) of anterior deltoid, posterior deltoid, biceps brachi and triceps brachi were recorded by an EMG amplifier Delsys (model DE2.2L) with surface electrodes. The data, including the shoulder and elbow torque, were calculated using a Matlab software routine. The results showed slower movements in PD patients and the differences between them and the healthy subjects scaled with the target. Trajectory was linear and both groups reached the target without significant errors. The joint and interaction torques exhibited a considerable alignment in PD patients, but not in healthy subjects which demonstrated more variable patterns. It was interesting that for both groups the net torques were adequate and showed distance effects, but the PD patients' torques values were always smaller than that of the healthy subjects. It can be concluded that the PD patients generated torques with little variability as a group. On the other hand, the healthy subjects can use different combinations of muscular and interaction torques. Such behavior can be a factor of contribution with the movement's harmony. Besides, joint and interaction torques were similar in healthy and PD subjects, with less magnitude to PD patients. They did not obey the linear covariation principle. The net torques showed a linear synergy, with effect of group and distance. One can conclude that Parkinsonians do not show qualitative differences in generating torques, but the small EMG activity and difficulty in modulating these bursts can contribute to small torque values and low velocity.

Equilibrium Point Control Cannot Be Refuted by Experimentally Reconstructing Equilibrium Point Trajectories

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In the literature it has been hotly debated whether the brain uses internal models or equilibrium point (EP) control to generate arm movements. EP-control involves the specification of EP-trajectories, time series of arm configurations in which internal forces and external forces are in equilibrium; if the arm is not in a specified EP,

it is driven towards this EP by muscle forces arising due to reflexes and muscle mechanics. EP-control has been refuted by researchers claiming that EP-trajectories underlying movements of subjects were complex. These researchers had used a KBI-approach, which involves applying force perturbations during movements of subjects and fitting a stiffness-damping-inertia (KBI) model to the kinematic responses. In this study we examined the validity of the KBI-approach with the help of an EP-controlled musculoskeletal model of the arm. We used the latter model to simulate unperturbed and perturbed maximally fast movements and optimized the parameter values of a KBI-model to make it reproduce as best as possible the kinematic responses. It was shown that estimated stiffness not only depended on the "true" stiffness of the musculoskeletal model but on all of its dynamical parameters. Furthermore it was shown that reconstructed EP-trajectories were in agreement with those presented in the literature, but did not resemble the simple EP-trajectories that had been used to generate the movement of the model. It was concluded that the refutation of EP-control on the basis of results obtained with the KBI-approach was unfounded.

Time Varying Properties of the EMG Signal During Isometric Maximum Voluntary Contraction

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The application of surface electromyographic (EMG) recordings for assessment of the neuromuscular system within the ergonomics, rehabilitation and sports physiology fields is well established. Two common parameters employed for describing the characteristics of the EMG signal concern the amplitude and the frequency distribution. Considering the signal as a realization of a stationary process may discard information about changes throughout the entire contraction, even during isometric constant force situations. This study aims at evaluating the time varying behavior of the surface myoelectric activity, both in time and frequency domains, during a short sustained maximum voluntary contraction (MVC). Twelve subjects, well trained on heavy resistance programs, exerted a sustained elbow flexion MVC. The total time of acquisition was 10 s, with the contraction starting at the first second. A bipolar configuration for detection of the EMG activity, producing one single differential signal was employed. Initially, the RMS estimator was considered for the amplitude description, applying a non-overlapping sliding window (250 ms) to the entire data. By means of the Short-Time Fourier transform, the mean frequency (MNF) was also estimated for every window. Both EMG and force data, for each subject, were normalized with respect to the peak value. For practical purposes, the segment of the mean signal corresponding to a constant force (6 s) was partitioned into three epochs of 2.0 s, and then, the one-way analysis of variance was applied to compare both parameters. The RMS and MNF presented an inversed trend, with the former increasing exponentially from the beginning of the contraction while the later declined linearly. This typical behavior is well documented for submaximal and maximal fatiguing tests, where the MNF decrement is related to myoelectric manifestation of muscle fatigue, being the reduction of the conduction velocity one of the most important factors. As this is not a desirable effect in MVC tests, where one value should be representative of the entire contraction, short-term contraction

tests are applied (2-10 s). When comparing the three intervals, both parameters were significantly different between the first and the last 2 s ($p = 0.02$ and $p = 0.01$ for RMS and MNF, respectively). In conclusion, this work shows that myoelectric parameters change in MVC tests, even when the force level is sustained for a short period, suggesting that tests with well trained subjects on heavy resistance programs should be longer than 4 s after maximum force stabilization, assuring higher myoelectric activity.

Emerging and Disappearing Synergies in a Hierarchically Controlled System

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The purpose of the study was to explore the ability of the central nervous system (CNS) to organize synergies at two levels of a hypothetical control hierarchy. Synergies were defined as patterns of co-variation among elemental variables that stabilized the output of the whole system. We investigated indices of finger force co-variation as reflections of synergies stabilizing the total force produced by a set of fingers in accurate force production tasks. Such indices computed for a finger pair within one hand depended on whether one or two hands were involved in the task. In one-hand tasks, the indices were positive (strong negative co-variation of finger forces), while in two-hand tasks, these indices were close to zero or negative. The differences between the synergy indices were significant during both steady-state and ramp force production. In a follow-up experiment, the subjects produced constant force with one or two finger pairs, and then added a finger pair or removed a finger pair without changing the force level. Adding (removing) a finger pair resulted in a dramatic drop (increase) in the synergy index, which could be seen without a time delay. The emergence and disappearance of force stabilizing synergies may signal a limitation in the ability of the CNS to form synergies at two different hierarchical levels. This conclusion contradicts evidence that the CNS organizes synergies at the level of the thumb-virtual finger and at the level of individual fingers in prehensile tasks. We hypothesize that the CNS has a library of well-learned synergies that can be used to build synergies at hierarchically higher levels. Massive practice may be required to lead to the creation of synergies at two hierarchical levels.

The Role of Period Differences on the Emergence of Unintentional Visual Coordination

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Previous research has demonstrated that a person's rhythmic movements can become unintentionally entrained to the rhythmic movements of another person or of an environmental event. There are indications, however, that in both cases the

likelihood of entrainment depends upon the difference between the independent or uncoupled periods of the two rhythms. The range of period differences over which unintentional person-environment visual coordination might occur was examined in two experiments. Individuals were instructed to swing a wrist-pendulum at a self-selected period while simultaneously reading aloud letters that flashed on a visually oscillating stimulus that was projected on a large screen. We directly manipulated the period of the visually oscillating stimulus with respect to the participant's natural period of movement and, thus, precisely controlled the range of period differences which the participants experienced. Cross-spectral coherence analysis and the distribution of continuous relative phase revealed visual entrainment up to but not exceeding a 15% difference between a participant's preferred period and the experimenter determined period of the environmental stimulus. These findings extend the dynamical systems perspective on person-environment coupling (reveal loss of attractors, a saddle-node bifurcation) and highlight the significance of period difference (smaller is better) to the emergence of unintentional coordination.

Attractor Strength Differences in Intra- and Inter-personal Interlimb Coordination

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Previous research has demonstrated that intra- and inter-personal rhythmic interlimb coordination are both constrained by the self-organizing entrainment process of a coupled oscillator dynamic. In particular, both intra- and inter-personal coordination exhibit the same stable macroscopic movement patterns (i.e., inphase and antiphase). The variability of inter-personal coordination, however, is typically found to be much greater than the variability observed for intra-personal coordination. Researchers have assumed that this is due to a difference in the strength of the attractor dynamic that underlies these two forms of rhythmic interlimb coordination. More specifically, the visual-motor coupling of inter-personal coordination is assumed to result in a weaker attractor dynamic than the neuro-muscular coupling of intra-personal coordination. Two experiments were conducted to evaluate this conjecture. Pairs of participants swung hand-held pendulums about the wrist either inphase or antiphase, both intra- and inter-personally. The cross-recurrence statistics of % REC and Maxline were used to independently index the level of noise and the attractor strength of the coordination, respectively. The attractor strength for inter-personal coordination was significantly weaker than the attractor strength for intra-personal coordination. However, the magnitude of noise underlying the two types of coordination was similar. Discussion will focus on 1) the ability of cross-recurrence analysis to independently index the noise and attractor strength of rhythmic interlimb coordination, and 2) possible reasons for a weaker attractor in visual-motor coupling than in neuro-muscular coupling.

S-Learning: A Sequence-based Learning, Memory, and Control Algorithm

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Summary: S-Learning is consistent with neurological and psychophysical observations of human motor behavior. Discrete-time sensory feedback is amassed real time to form a dynamic model of the controlled system and its environment; no explicit model is provided. S-Learning serves as both biomimetic robot control architecture and a model of human motor learning. *Method*: The concept underlying S-Learning is simple—an agent stores sequences of motor commands and sensory states for future use. With this experience base, the agent is able to predict future states, effectively bootstrapping a dynamic model. To achieve a goal or to adapt to a new environment, the agent selects an appropriate sequence from among its previous experiences. Due to the nature of sequence storage, S-Learning maintains information relevant to achieving many goals, an attribute that differentiates it from nearly all neural network and temporal difference algorithms, including Q-Learning. S-Learning is an example of the notion of embodiment, where all learning and goal seeking behavior is based solely on the agent's interaction with the environment. *Biological Relevance*: The discrete nature of human motor commands (e.g., submovements and saccades, Woodworth, 1899) and sensory experiences (van Rullen & Koch, 2003) are assumptions upon which S-Learning is based. Thalamocortical structures suggest that processing is conducted in periodic steps and stored sequentially. (Rodriguez, 2004) Cerebellar-cortical-basal-ganglionic loops are likely candidates for classifying and selecting between multiple competing sequences. (Houk, 2005) These neural computation elements form the core of S-Learning. *Results*: In simulations of visually-guided grasping and point-to-point reaching tasks, S-Learning displays several attributes of human motor behavior, including learning through exploration, task transfer, and probabilistic convergence to optimality (as in Todorov and Jordan, 2002). S-Learning produces reaching movements qualitatively similar to both those of infants (von Hofsten, 1991) and stroke patients (Rohrer et al., 2004) In a robotic demonstration, S-Learning drives a Segway-mounted seven degree-of-freedom arm. *Conclusions*: S-Learning is a biologically plausible method of bootstrapping an internal dynamic model; it is an unsupervised learning technique suitable for unstructured environments. Indeed, as observed by Houk (2005), the nature of such an agent may be general enough to serve as a basis for phylogenetically more advanced functions, including cognition. By virtue of its grounding in specific brain structures and ease of implementation in robotic hardware, S-Learning provides a valuable strawman model for the investigation of human motor behavior.

Evolution of the Gross Motor Function of Cerebral Palsy Patients Treated During a Basic Bobath Course

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Introduction : The Bobath's concept main principles are specific preparation for goals, use of concepts of motor control and motor learning with active participation of the patients, functional goals and practice, emphasis on quality of movements and individually planned treatment. Key points of control are used to influence postures and movements. *Purpose*: To evaluate the motor improvement in the group

of patients who were treated in a Bobath course and to see if this improvement is more significant than another group of patients who were treated by therapists who were not Bobath trained. *Subjects*: Sixteen subjects age 1 year and 4 months to 7 years and 8 months, mean age 4 years. The control group ($N = 8$) and experimental group ($N = 8$) were matched for age, quality of tonus (spasticity or athetosis), level of GMFCS (Gross Motor Functional Classification System), initial score of GMFM (Gross Motor Function Measure). *Methods*: Controlled trial. The experimental group was treated in a Basic Bobath course and the control group continued to receive the same classical treatment they were receiving before the assessment. For both groups only physiotherapy treatment hours (10 hr + or -1) were computed because the main point of this study was the gross motor function. The method of assessment was GMFM-66 that was applied just before the beginning of the treatment at Bobath course for the experimental group and after 10 hr (+ or -1) of physiotherapy treatment. In the control group the GMFM was applied and the next session started to count the 10 hr (+ or -1) of classical physiotherapy treatment and the patients were regularly being treated, as established. *Analysis*: Student's *t*-test was used. *Results*: GMFM detected gross motor functional changes showing $t = 2.36$ and $p = 0.03$ for the experimental group. *Conclusions*: The experimental group had a greater statistically significant improvement in motor gross function than the control group. For other studies we planned a larger sample as well as the study of the difference of evolution between spastic and athetosic patients using GMFM assessment. They seem to be different.

Whiplash Associated Disorders

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Introduction: Whiplash-associated disorders (WAD), as defined by the Quebec Task Force, are a common diagnosis after neck trauma, caused by sudden acceleration and deceleration forces acting on the head and neck, most typically related to rear-end or side-impact car accidents. Since physical injuries seldom are found with present imaging techniques, the diagnosis can be difficult to make. The active range of motion of the neck is often visually inspected in patients with neck pain, but this is a subjective measure, and a more objective decision support system, that gives a reliable and more detailed analysis of neck movement pattern, is needed. The objective of this study was to evaluate the grading ability of a unsupervised self organizing maps (SOM) network when presented with neck movement patterns as input and using the individual subjective neck pain and disability index (NPAD) as an indication of the condition of the subject. *Method*: Three-dimensional neck movement data from 59 subjects with WAD and 56 control subjects were collected with a ProReflex system. Rotation angle and angle velocity were calculated using the instantaneous helical axis method and motion variables were extracted. A principal component analysis was performed in order to reduce data and improve the SOM network's performance. Each subject had to complete a questionnaire, before the study begun, which was used for the calculation of the NPAD index. One vector, containing the movement pattern, for each subject was then presented to an SOM network, configured with different number of hidden nodes, during a

training session. The NPAD index was used in combination with the classification of the SOM network in order to visualize the result. Each hidden node represents a class within the SOM network, e.g., if an SOM network has two hidden nodes it tries to classify the movement patterns into two categories. *Results and Conclusion*: The results show that when using an SOM network with two hidden nodes it is possible to classify the subjects as control or WAD with a predictivity of approximately 85%. If only WAD-subjects are used as input to an SOM network with two hidden nodes there is a classification of subjects with NPAD greater than 60 in one category and those with less than 60 in the other category. In conclusion, this method seems promising when developing a tool for grading of WAD but further evaluation is needed.

A Fully-Coupled Metronome/Actor System

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A new experimental paradigm is introduced in which an oscillator producing a metronomic signal is coupled to the actions of the actor attempting to coordinate with it. This has several implications for the study of coordination from the perspective of dynamical systems theory. First, this generates a system in which the dynamics are fully coupled, unlike the usual metronome paradigm, in which the metronome affects the actor's behavior but not vice versa. Second, the detailed dynamical properties of one-half of the coordinating system are experimentally specifiable and thus fully known, namely, the dynamics of the oscillator and the coupling it receives from the actor, unlike the situation in other coordination paradigms such as interlimb coordination, where the entire system is a priori unknown. Finally, by recording and analyzing the oscillator's time series behavior we can more easily reconstruct the phase space of the full system, as compared with less completely defined systems. The promise of the paradigm is indicated in two experiments, one involving discrete pulse coupling, which connects to the literature on synchronization with a metronome via discrete taps, the other involving continuous coupling, which connects to the literature on interlimb coordination.

Effect of a Train of Epsps in the Repetitive Discharge of Motoneuron Models with Passive Dendrite

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In motoneurons, an individual train of excitatory postsynaptic potentials (EPSPs) can be simulated by an injection of a suprathreshold step current in soma and a posterior addition of short duration current pulses. Thus, we can verify a modulation in the motoneurons firing rate owed to the current pulses superimposed, and a sublinear relationship between the increase in the mean firing rate and the pulses frequencies can be observed, with a saturation tendency at 400 Hz (Powers & Binder, 1996). The aim of this work was to evaluate, by computational simulations, the repetitive response of motoneuron models with passive dendrite when an injection of currents simulating an individual train of EPSPs, in different

frequencies, durations and amplitude was performed. The simulations were accomplished with compartmental motoneuron models of different types (S, FR and FF), whose geometry and electrotonic parameters were based on classic works of the experimental literature with lumbar-sacral motoneurons of cats, and the dendrite was passively modeled (Vieira, 2002). Suprathreshold step currents with 1 s duration and sufficient amplitude to evoke discharges in basal frequencies of 12 and 22 imp/s were injected in the models' soma. Afterwards, those pulses of currents with variable amplitude, duration and frequency were superimposed, and the difference between the mean firing rate with or without the pulses was measured (Elias &Vieira, 2005). In order to compare the results obtained by the simulation and the experimental data, the function based on the effective synaptic current and the saturation function, reported by Powers and Binder (1996) were used. It could be verified that the current injection that simulates an individual train of EPSPs increases the mean firing rate of the motoneuron models, observing, in all cases, a sublinear characteristic between the increase in the firing rate and the pulses' frequencies. However, the saturation of these curves could be noticed in values that were different from those described in experimental literature. In the type S and type FR models, saturations were observed in the range of 50-300 Hz, and the type FF model was observed at pulse rate of 300-450 Hz. When compared to the functions based on the effective synaptic current and the saturation function, all the results are similar to those reported in other papers, where the first function underestimates all the values and the second underestimates the lowest frequencies and overestimates in higher EPSPs frequencies, showing that the models well represent the phenomena studied.

Simulation of the Accommodation Phenomena In Motoneuron Models with Passive Dendrite

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The mechanisms involving the motoneurons accommodation are related mainly to changes in the fast sodium conductance and the potassium conductance. Long latencies are suggested in spinal, and mesencephalic cat motoneurons, assuming slow accommodations, although experimental observations show that fast accommodation can occur (Frank & Fuortes, 1960; Schlue et al., 1974a, 1974b, 1974c). Mathematical models of motoneurons were evaluated under their accommodations when an injection of ramp current was simulated in their soma. Different accommodation rates were evaluated in the models in order to classify them as slow accommodation group or fast accommodation group, besides providing useful data to support the experimental research. In this study, compartmental motoneuron models of different types were used (S, FR and FF), whose geometric and electronic parameters can be found in classic works of the experimental literature with lumbar-sacral motoneurons of cats, and the dendrite was passively modeled (Vieira, 2002; Vieira & Kohn, 2005). In order to simulate slow excitatory actions, a ramp current with variable slope in order to evoke repetitive discharges was injected in the soma of the models. The time of the first action potential was registered, and also the current intensity capable to evoke these discharges. Therefore, a relationship between the current intensity and the latency was measured, and the resultant

curve was named threshold latency curve (TL-curve). The accommodation rates were calculated by the relation between the current intensity of a 1 s ramp current with a slope sufficiently able to evoke one discharge and the previously calculated reobase current (I0) of the models (Elias & Vieira, 2006a, 2006b). It could be verified, in all the models, that the TL-curves present similar results to experimental data reported in the literature, and there is a steady range with low intensity of current for low ramp slope and a linear range for high ramp slope. For the accommodation rates, values of 1.463 for type S model, 1.456 for type FR, and 1.418 for type FF were reported. With these results, we can conclude that the models represent slow accommodation motoneurons, since the accommodation rates were always less than 1.6 (Schlue et al., 1974a, 1974b, 1974c). However, the results were quite close among the models as might occur by the similar modeling in the fast sodium conductance, and the potassium conductance, both responsible for accommodation mechanisms in vertebrate motoneurons.

Surface EMG to Study the Motor Unit Interspike Intervals Variability: Electrode Location, Recording, and Signal Processing

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The electric signals of the peripheral skeletal muscles provide important information about the motor units to which they belong, and indirectly, we can infer about the properties of the motor control system in humans. We can monitor the electromyographic signals (EMG) in two basic ways: using needle or wire electrodes (invasive methods), or using surface electrodes (non-invasive methods). An important characteristic that must be verified in the motor control system in vertebrates (e.g., cats, humans, etc.) is their interspike intervals variability (Calvin & Stevens, 1968), and this can be verified through the electromyographic activity of the peripheral skeletal muscles (Sturm et al., 1997; Poliakov, et al., 1995), or through the direct detection of the action potentials in the motoneuron (Calvin & Stevens, 1968). The aim of this work was to propose an experimental protocol for the evaluation of the motor unit interspike intervals variability of the soleus muscle, using the surface electromyography (sEMG), thus supplying a fast and effective answer about an important physiologic mechanism. Our protocol proposes the placement of the circular surface electrodes (Ag/AgCl; diameter–10 mm), with 2 cm of interelectrode distance in a bipolar differential detection. Those electrodes should be positioned 4 cm below the junction of the two heads of the gastrocnemius muscle in a lateral portion, guaranteeing the placement of the electrodes in the soleus muscle area, between the innervation zone and the tendon zone. A reference electrode was positioned in the wrist of the analyzed individuals. The active sensors were pre-amplified with 20x gain and CMRR > 100 dB, and a 16-bit ADC with 100x gain was used to digitize the signal with 2,000 S/s. The electromyographic activity under the condition of an isometric volunteer contraction of low intensity (plantar flexion) was registered, and the data were stored in a personal computer, where they have been filtered through a band-pass filter (10-500 Hz, Butterworth, fourth order) for artifacts elimination. A computer program, written in Matlab language, detects the action potential picks belonging to the same motor unit, and calculates the interspike intervals, where we can infer about the statistics of these

intervals, and visualize the variability of them. With this protocol, the data concerning the interspike intervals variability of the soleus muscle could be obtained, thus inferring about the behavior of the motor control system in humans using a non-invasive method.

Experimental Data of the Motor Unit Interspike Intervals Variability of the Soleus Muscle

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When the motoneuron discharges with a steady mean frequency, the information is probably transmitted in the interspike intervals. However, there is an intrinsic variability of the nervous system, which is also verified in interspike intervals. This variability is an important physiological mechanism, because it is capable of establishing an accurate relationship between the receptor and its stimulus. Besides, a variable and noisy output contributes to a softer mechanical response. In vertebrates, it can be observed that the main sources of variability are the synaptic input variations in motoneurons (synaptic noise), since this element should integrate a great quantity of postsynaptic potentials in the time and space in the synaptic sites (Calvin & Stevens, 1968). In this study, we collected experimental data concerning the motor unit interspike intervals variability of soleus muscle in humans. Therefore, an experimental protocol was developed: data was acquired in three individuals (men only), without neuromuscular disorder and who were aged between 21 and 45 years, after they have signed the consent form. The subject remained seated on a rigid bank with adjustable height, with his hip and knee bent 90°, his feet completely on the ground, and his ankle in neutral position. The electrodes were disposed as described in the previous article (Elias & Vieira, 2007). Volunteers had been instructed to keep in isometric plantar flexion, in order to produce clear discharges from a single motor unit. After verbal command, acquisitions were made for 2 min, and the electromyographic signals were supplied as feedback to the volunteers. The experimental data were processed in Matlab and the histograms and statistics of the interspike intervals were calculated (mean, standard deviation, coefficient of variation, kurtosis and skewness). In all cases, 20 and 40 s acquisitions were made, which is sufficient time to discharge a single motor unit. However, in these periods, there were never less than 120 samples, a sufficient number to infer on the intended mechanism. The motor units presented firing rate of 6.45 ± 0.87 imp/s (mean ± SD), presenting slow motor units (type S). The histograms already presented a leptocurtic characteristic (kurtosis – 19.16 ± 21.47) and positive deviation (skewness – 2.69 ± 2.08), similar to those reported in the experimental literature related to muscles whose motoneurons pool is located at the lumbar area. (Poliakov et al., 1995; Vieira, 2002). The coefficients of variation were located in a range between 0.086 and 0.255, but the highest value was between 0.130 and 0.160.

How Does Steady-State Force Production by One Hand Affect the Oscillatory Dynamics of the Other?

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During the performance of motor activities, such as walking or running, muscle forces generated in one body segment can affect the motion and position of segments far removed from it. As a result, the musculoskeletal system is required to deal with the resulting stresses caused by the flow of forces through the kinetic chain. Counteracting these forces locally during the performance of motor tasks is not only unlikely to succeed in a highly integrated system, but is also ineffective (Schenau & Soest, 1996). Bernstein (1967) proposed that movement is organized so as to take advantage of the context of forces in the whole system when a motor task is performed. Under this perspective, advancements in our understanding of movement organization rely on a better appreciation of the remote effects of locally produced forces. The objective of the study was to describe the effects of a tonic force produced at one wrist on the observed kinematic pattern and oscillatory dynamics of the rhythmic movements generated by the opposite wrist. Seven participants were asked to swing a single hand-held pendulum at a comfortable tempo (with amplitude unconstrained) while continuously squeezing a dynamometer with their other hand. The experimental protocol involved nine different conditions obtained through a combination of three pendulum lengths with three levels of force. Mean amplitude and period were computed from the pendulum displacement time-series obtained in each trial. The oscillatory dynamics were evaluated by a graphical and statistical method developed by Beek and Beek (1988). This analysis revealed a change in the linear and non-linear stiffness functions underlying the rhythmic movements produced by one hand as the level of force generated by the other hand increased. These effects were observed along with increases in the amplitude of oscillation. The results suggest a reorganization of the oscillatory dynamics as a function remote force production. It is possible that this reorganization allowed the system to take advantage of the changing context of forces during the performance of the rhythmic movements. Different hypothesis will be discussed regarding the nature of effects observed.

Evaluation of Kinesiotherapeutics and Proprioceptions Resources Applied in the Motor Recovery of Wistar Rats Submitted to Moderate Contusive Spinal Cord Injury

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Introduction: Spinal cord injury (SCI) results in permanent motor and sensorial deficits. The physical activity associated with sensorial-motors facilitative processes improves the motor and sensorial function after neurological trauma in clinical and in animal models (Hutchinson, 2004; Lieberman, 2005). *Objective*: To evaluate the motor function (MF) recovery of rats with SCI, submitted to physical training (FT)

through kinesiotherapeutic and proprioception tasks. *Methods*: Wistar adult rats (N = 50) were divided into five groups. Three were trained before and after SCI (NYU-Impactor-MASCIS), in three different apparatuses developed at our laboratory: 1) with offer of sensorial and proprioceptive information along the course (Maze-MAZE) (N = 11); 2) with offer of forced articulate movement of hindlimbs on a ramp (Ramp-RAMP) (N = 8) and 3) Runner Trace (RUN) (N = 10). Animals of the SHAM group (N = 11) were submitted to laminectomy in T9 without SCI and the Control group, with SCI-CTL (N = 11) and did not receive FT. Except the animals of the CTL group, all the other groups were trained by 12 min (medium), twice a week for 2 weeks prior to the SCI and five subsequent weeks after SCI. The behavioral testing was accomplished through the MF analysis by open-field BBB scores (Basso, 1995). *Results*: The animals submitted to FT presented significant statistical difference among the groups in the evolution of MF for both sides of the body ($p < 0.0001$). The temporary evaluation of the first 3 weeks of FT in our apparatuses showed premature recovery of MF for both sides of the body in the animals with SCI ($p < 0.0001$). *Conclusions*: The animals submitted to FT in the apparatuses (MAZE and RAMP) presented improvement in relation to the RUN and to the others without FT, probably due to the different offered incentives. That improvement reaffirms the need of precocious interventions in SCI. Once the rehabilitation depends on sensorial-motors facilitative processes (Lieberman, 2005), we could infer that FT accomplished in our apparatuses has been effective in the feedback of information, such as force, speed and displacement which are propitious to rehabilitation. Such sensorial extereoceptive information presented by different sensorial ways in the use of our apparatuses will be able to help in the improvement of a therapeutic experimental model. (Financial support: CAPES, FFM, HC-FMUSP.)

Human Position Monitoring Based on External Referent Body Configuration

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We propose to develop an intelligent system for measuring and capturing the configuration of the human body. The initial proposed use of the system is in physical therapy applications, where it is important that a patient maintain correct sitting/standing posture. The functioning of the system reflects the principle of referent body configuration organized by the nervous system in spatial coordinates. The medicinal effect of the system is based on the assumption that the physical therapist can define some optimal coordinates of referent configuration conforming to the individual parameters and state of the subject. Additional applications of the underlying technology include motion tracking, gaming, advanced human-computer interaction, as well as collision avoidance, robotics and other industrial uses, where position of an object or a group of objects needs to be tracked in real time. The system continuously monitors the patient's posture and reports the collected data to a central location for analysis and processing. A set of sensors is located on selected points on arms, feet, and torso. Each sensor contains an ultrasound transmitter (piezoelectric ceramic resonator) and an acoustic receiver (detector). High reliability of the device is provided by roll-call algorithm of inter-sensor communication, and

cross-correlation technique for calculating the distances between their positions. The distances are fed to an algorithm of three-dimensional scaling calculating sensor coordinates in Cartesian space. These coordinates are compared with the referent configuration assigned by the physical therapist. The therapist can evaluate the posture and give instructions for improvement, make decisions about patient's response to treatment, etc. In the autonomous feedback mode, the system presents an acoustic (or visual) signal about the difference between the "external" referent and actual configurations. This short posture correction message helps the subject to return to the "correct" position. The process of correcting the body position can be considered simultaneous multi-directional reaching to several targets opening a wide spectrum of experimental setups. The principle of referent body configuration utilizes the indices of the minimum of EMGs for additional estimation of the body configuration, more individualized and detailed than the sensors positions.

Comparative Analysis of Isokinetic Parameters: Time to Peak Torque and Acceleration Time Between Men and Women

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Objectives: The aim of this study is to compare isokinetic dynamometer parameters related to torque development between healthy and active men and women. *Methods*: Twenty-three subjects, 13 women (mean age 32.15 ± 4.47 years) and 10 men (mean age 33 ± 9.16 years) participated in this study. For inclusion, they were not athletes and had no neuromuscular diseases or upper limb dysfunction. The subjects were submitted to a concentric isokinetic test of elbow flexion and extension with an isokinetic dynamometer (Biodex Multi-Joint System 3), when time to peak torque (TPK) and acceleration time (AT) were evaluated at the velocities: 60, 90, 180 and 240°/s, with 5, 10, 15 and 20 repetitions, respectively. The statistical analysis for gender comparison, in each velocity, was made by the unpaired *t*-test. *Results*: The TPK was greater for women at 240°/s speed ($p = 0.0238$). The AT showed significant difference between gender in all velocities, presenting superior values for women ($p = 0.001$). *Conclusion*: Considering acceleration time arise information about neuromuscular dynamic responses, the present results suggest that muscular fiber recruitment was retarded when maximal torque was solicited in women, comparing to men.

Tensegrity Perceptual Hypothesis

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Auditory perception and haptic perception are grounded in contact mechanics and mechanoreceptors. The auditory perceptual system is embedded in a homogeneous, compressible medium (air or water) that when compressed by mechanical disturbances acts to eliminate the compression. The consequence is a vibration field of

wave fronts and wave trains with the geometry of the wave fronts and the invariants of the wave trains information about distal mechanical events. We hypothesize that the haptic perceptual system is similarly embedded in a compressible medium, one that is constituted by a nesting of tensegrity structures. These are structures whose shape and stability derive from continuous tension and discontinuous compression. For the body as a whole, the muscles, tendons, ligaments, and fascia (infused with mechanoreceptors) are the tension elements and the bones (suspended within the tension network) are the compression elements. Mechanical disturbances, self- or other-induced, are realized as changes in the force balance in the tension distribution. In our hypothesis, the array of tensions in the body's tensegrity structure, its transformations, and invariants under those transformations, constitute the basis of information about the body and about adjacent surfaces or objects in contact with, or attached to, the body.

Are We Measuring Motor Ability?

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A number of test batteries are used to identify children with motor difficulties such as dyspraxia, developmental coordination disorder (DCD) or motor learning difficulties (MLD). These batteries implicitly assume a higher order construct since they provide a composite score as an indicator of overall motor performance. In this study, we use Burton and Rodgerson's (2001) theoretical taxonomy of motor behavior to guide the interpretation of an assessment tool. In this study we investigated the hierarchical structure of the McCarron Assessment of Neuromuscular Development (MAND) (McCarron, 1982) to ascertain the first order factors and whether there were higher order factors. The MAND battery has 10 items measuring a range of motor skills noted below. Motor scores were obtained from a subsample of 1,619 ten-year-olds (boys = 842, girls = 777) from the longitudinal Western Australian Pregnancy Cohort (Raine) Study. Principal components analysis with Promax rotation yielded three factors with eigenvalues ≥ 1 and explained 49% of the variance. The first 1st order factor, which we called stability, explained 26% of the variance and included one foot stand, heel-toe walk, finger-nose, rod-slide and finger tap (factor loadings .69 - .39). The second factor, called dexterity, explained 12% of the variance and comprised nut and bolt, beads on rod and beads in box (factor loadings .74 - .71). The third 1st order factor, called muscle power, explained 11% of the variance and included grip strength and standing broad jump (factor loadings .84 - .60). All three 1st order factor scores were used in the second order principal component analysis. Only one component, with an eigenvalue ≥ 1, was extracted, which explained 45% of the variance. All three 1st order factors contributed providing psychometric evidence of a higher order abstract construct. The first order factors were consistent with movement skill foundations as represented in Burton and Rodgerson's (2001) taxonomy, but did not support a taxonomic division into

fine and gross motor skill sets. The second order factor is consistent with their general motor ability construct. In order to achieve a high score on the McCarron battery, a child had to respond to complex and varied motor task demands often in an unfamiliar environment. There is a need for further debate and research into the meaning of higher order constructs. For example, are we measuring motor ability or kinaesthetic intelligence?

Nonlinear Dynamical Models of Inter-Trial Task Execution

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Throwing a ball, playing darts, pounding a nail with a hammer, or even just touching your nose: What factors determine the precision and repeatability of skilled human movements such as these? We describe a class of discrete dynamical systems for modeling repeated, goal-directed, kinematically redundant human movements. These task dynamical systems model the trial-to-trial execution of a task under the influence of the environment, task geometry, and inter-trial error correction. We discuss the use of such models to study the dynamical origin of human movement performance variability. The approach uses a mathematical definition of movement tasks in terms of goal functions. Each goal function can give rise to an associated goal equivalent manifold (GEM) (Cusumano & Cesari, 2006), which contains all body states exactly satisfying the task. The effect of GEM passive sensitivity on goal-level performance is demonstrated and used to evaluate different task strategies. We show how the GEM behaves under coordinate transformations between the execution variables, kinematic variables at the level of the end effector, and action variables, which correspond to the generalized forces and times needed to move the limbs within one trial. A hierarchical control scheme involving in-trial action templates and inter-trial stochastic optimal error correction is included to generate a nonlinear map for the repeated execution of the task. This general model template allows one to examine how model assumptions and GEM geometry affect goal-level performance statistics. The general theory is illustrated using a simple throwing task. It is shown theoretically how the performance, measured by the RMS error at the goal, results from factors of passive sensitivity, the magnitude of body fluctuations, the orientation of fluctuations with the GEM, and the stability properties of the inter-trial controller. The action of the inter-trial controller developed for our model system is simulated and is shown to closely agree with the theoretically predicted performance. The inter-trial dynamics with a controller based on the Minimum Intervention Principle (Todorov & Jordan, 2002) are shown to exhibit random walks, the properties of which depend on controller nonlinearities and GEM geometry. The effect of this behavior on performance variability is demonstrated. The implications of these results for the analysis of data from human subjects are discussed.

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Body-Goal Variability Analysis of Performance

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The large numbers of joints and muscles of the human body give rise to equifinality (Bernstein, 1967) in task execution. That is, there are typically an infinite number of body configurations that can achieve the same goal. This set of configurations is now known to be in many cases of practical importance to have the structure of a manifold (Scholz & Schöner, 1999). In this work, we use this fact to develop a new type of experimental task performance analysis based on the idea of a body-goal variability mapping (Cusumano & Cesari, 2006). We show how this mapping arises naturally from the idea of a goal function that theoretically defines a task and directly determines the goal equivalent manifold (GEM), the set of all possible task solution strategies. In addition, the body-goal map determines the sensitivity of different strategies to perturbations in the body state during execution, and thus can be used to show that even though two different strategies may be geometrically goal-equivalent (i.e., lie within the GEM), they may not be equivalent in their robustness to perturbation. The experimental application of these ideas does not require a detailed kinematic model, but instead is uses data to estimate the body-goal matrix that relates body and goal-level variability. This results in a characterization of the sensitivity of goal-level errors to body-level perturbations. We show how the goal-level performance can in general be decomposed into factors involving sensitivity, GEM alignment, and body variability. The method is applied to the analysis of redundant kinematic data from subjects performing an aiming task carried out with and without a laser pointer. The results show that the decomposition obtained from the body-goal map allows one to see how a specific performance level is achieved by a given subject, and to distinguish the behavior of subjects even when their goal-level performance is indistinguishable. The analysis also allows one to see precisely how subjects respond to changes in perceptual information (laser on/laser off) and precision requirements (target size). We find evidence that control is exerted on all factors in the body-goal performance decomposition, not just that related to GEM alignment.

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Brazilian Version of the Short Physical Performance Battery SPPB: Cross-Cultural Adaptation and Reliability Study

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This study was intended to carry out a cross-cultural adaptation and to evaluate the reliability of the Short Physical Performance Battery–SPPB for the Brazilian

elderly population. The methodological stages recommended by specialized literature were adopted: translation, back-translation, expert committee, pre-test and evaluation of the reliability of the Brazilian version. The pre-test consisted of a sample of 38 elderly (78.95% were women), at an age average of 71.26 years (SD = 9.03) and the involvement of 27 health care professionals. If more than 15% of therapists or patients reported difficulty in understanding any item, such item was reformulated and reapplied. To verify the reliability of the SPPB final version, two physiotherapists checked out 30 other elderly individuals, at an age average of 77.03 (SD = 9.51) years, 17 of them were women (57.67%). The reliability analysis showed the following measurements: internal consistency ($\alpha = 0.725$), according to Cronbach's coefficient; interobservers (ICC = 0.996) and test-retest (ICC = 0.876), the last two ones, from intraclass correlation coefficient ($p < 0.001$). Each test score as compared to SPPB total score was also analyzed, according to Spearman's correlation coefficient, resulting: $r = 0.703$ to the balance test, $r = 0.898$ to the gait speed test and $r = 0.769$ to the chair stands test (all $p < 0.0001$). In conclusion, the SPPB Brazilian version applied to the studied elderly group has revealed good reliability and recommends further psychometric property studies to confirm the SPPB validity to the Brazilian elderly population.

Comparison of Time to Peak Torque and Acceleration Time Between Healthy Men and with Myopathy

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Objective: The purpose of this study was to compare different parameters determined by isokinetic dynamometer between healthy men and subjects with myopathy. *Methods*: Eighteen subjects were divided into two groups: nine healthy men, with no neuromuscular diseases or upper limb dysfunction (mean age 32.22 years ± 9.36) and nine men with myopathy diagnosis, confirmed by muscular biopsy, (mean age 40.22 years ± 11), participated in this study. The functional test was realized by an isokinetic dynamometer Biodex Multi-Joint System 3 and the subjects realized concentric elbow flexion and extension. Peak torque (PK), time to peak torque (TPK) and acceleration time (AT) were evaluated at the velocities: 90 and 180°/s, with 5 and 10 repetitions, respectively and a 4 min rest. The statistical analysis for comparison of the groups, in each velocity, was made by the unpaired t test. *Results*: There was no significant difference between the groups in both velocities to PK, TPK and TA values, respectively (90°/s: $p = 0.97$; $p = 0.78$; $p = 0.54$; 180/s: $p = 0.97$; $p = 0.86$; $p = 0.7$). *Conclusion*: The group composed of subjects with myopathy showed similar functional characteristics as the health subjects. Probably, the subjects with myopathy performed a heterogeneous group presenting morphological, biochemical and/or functional disturbances of the muscles for which the isokinetic test would not have detected a difference.

The Skilled Forelimb Reaching In Wistar Rats: Evaluation By Montoya Staircase Test

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Experimental animals, mainly rats and mice, have been used in several studies of neurological diseases. Their performance in behavioral tests is useful to evaluate the success of specific effects of lesions procedures as well as to access the pattern of functional recovery after different types of treatment (Biernaskie & Corbett, 2001; Whishaw et al., 2003; Windle et al., 2006). Despite the widespread use of animal models in functional rehabilitation, sometimes little consideration is given to lineage selection and related effects on skilled forelimb use. The Staircase Test was initially described by Montoya et al., 1991 and allows a sensitive measure of bilateral skilled reaching. The task consists in reaching for food inside a special box with a central platform and adjacent staircases. The forelimb ability is assessed by means of the record of pellets eaten, dropped and remaining on the steps. The purpose of the present study was the characterization and evaluation of the Staircase Test for inbred albino Wistar rats before and after brachial plexus crushing. Fifty-eight male adult Wistar rats housed under standard laboratory conditions were used. They were trained during 3 weeks before the surgery, two trials of 15 min per day (total: 24 trials). Then, they were retested 24 hr and 7 days after the crushing procedure at the same daily frequency and time. Results demonstrated no forelimb preference to do the reaching, 56.9% of animals preferred the right while 25.9% of animals used more the left and 17.2% showed no paw preference. The scores with right paw (11.8 ± 3.5) were very similar to those obtained with the left (11.1 ± 3.6), although more pellets could be reached with the preferred paw (12.6 ± 3.2) when compared with the not preferred one (10.2 ± 3.5; $p = 0.0002$). As to reach, the criterion of a minimum of 18 pellets eaten, 10.5 ± 4.4 trials were necessary, nevertheless just 69% of the animals attained that performance. This analysis will be useful to perform other trustworthy behavior studies with Wistar rats.

Years of Education Can Influence on Dual-Task Performance: Mutual Interference Between a Visual and a Motor Task

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Introduction: The association of visual and motor tasks is common in daily life activities, such as crossing a street or driving. Illiterates or individuals with few years of education can present difficulty in concurrent tasks, since going to school during childhood influences brain organization. Although many studies have presented the impact of formal education on cognition, little is known about the different aspects of its influence on motor control. *Aim*: The aim of this study is to investigate the possibility of occurrence of negative interaction between a visual and a motor task and to assess the difference between many and few years of education on individuals performing these tasks. *Method*: Twenty-eight healthy volunteers of both sexes participated in this study. Sixteen had 11 to 20 years of education

(16.33 ± 4.18 years of education; 36.53 ± 9.41 years of age: G1) and were paired to 12 volunteers who had 0 to 5 years of education (3.33 ± 1.92 years of education, 39.91 ± 9.99 years of age, G2). All volunteers scored 23-30 on MMSE. The visual test measured the accuracy of recognition of two visual targets of 150 ms (bus/bus, bus/truck, truck/bus, truck/truck), were presented simultaneously: one appearing at the fixation cross and one appearing in one of eight peripheric positions. The volunteers had to verbally classify whether the targets were equal or different. The answer was typed by the examiner. This test had one block of 32 trials. The number of errors and the duration of the visual test were registered. The motor task consisted of alternating steps from the ground to a 10 cm platform and had the same duration as the visual test. The number of alternations was videotaped and counted. *Results*: G2 was slower than G1 at the motor task ($p = 0.049$). G2 were less accurate at the visual task ($p = 0.035$). Both groups were slower at the motor task when they had to perform it compared to the visual task (dual task condition) ($p = 0.012$) and also less accurate at the visual task at the dual task condition ($p < 0.001$). *Conclusion*: The years of education of the volunteers must be considered not only when assessing cognitive tasks, but also for motor tasks. Simple tasks such as alternating steps can be influenced by the years of education of the volunteers. Individuals with few years of education seem to have difficulty in dual-tasks.

Learning and Development

Changes In Students' Manipulative Skills as a Result of 10 Weeks Intervention in Finnish Elementary School

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The aim of the study was to analyze changes in students' manipulative skills through 10 weeks intervention in a Finnish elementary school. The intervention consisted of weekly lessons in experimental schools. The students in the control group did not get any treatment. The intervention lessons included practicing versatile manipulative skills performed by hands and feet. The participants forming the experimental group of the study were 19 second-grade students. The control group consisted of 17 students at the same age. The study was quasi-experimental in design because it was not possible to randomly divide participants into experimental and control groups. Participants were analyzed by a set of tests measuring manipulative tests. The tests included the accuracy throwing from 3 m to a target, throwing and catching combination, and dribbling by feet. All of these tests have been found to be reliable and valid tools to analyze children's manipulative skills in Finnish sport and physical education contexts. A MANCOVA was conducted in order to examine differences in children's manipulative skills in the end measurement between experimental and control groups. Multivariate effect emerged in experimental condition [Wilks' lambda = 0.762, $F(3,22)$, $p < 0.05$]. The results of ANCOVAs showed that the dribbling test was the only test where statistically significant difference between experimental and control groups was found ($F = 8.09$, $p < 0.01$). The experimental group increased their dribbling skills during the intervention compared with the control group. There were no differences in

accuracy throwing and throwing and catching combination between experimental and control groups. Manipulative skills are considered to be among basic motor skills and thus very important to children's motor development. The results of this study showed that it is possible to increase their manipulative skills by emphasizing those performances in teaching. This study also revealed that it is easier to affect manipulative skills performed by feet compared with the skills performed by hands. This may be due to the fact that children do not have practiced so much dribbling and other manipulative skills performed by feet than they have by hands.

Internal and External Variability in Skill Acquisition and Control

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Performance variability has played a central role in motor control and has served as a window into the determinants of skill acquisition and performance. Performance variability is specifically informative when a task is redundant, i.e., the same performance result can be obtained in different ways. The putative human "motor noise," a low level of fluctuations pervading all aspects of performance, can be channeled in ways that do not affect performance. The present study examined a virtual throwing task in which 18 subjects performed a throwing movement in a virtual environment using a manipulandum trying to hit a target. Release angle and velocity of the manipulandum fully determined the error measured by the distance from the target. The task is redundant as different combinations of the execution variables, angle and velocity, lead to the same result. The nonlinear function from execution to result variables defines a nonlinear manifold containing the set of all successful solutions. Based on this task representation, two experiments tested whether subjects improved their results by maintaining and reorganizing their variability in execution space. In experiment 1, subjects performed three sessions to improve their performance. Two hypotheses were contrasted: 1) subjects are sensitive to their internal noise and find solutions on the manifold with the highest probability of success; 2) subjects seek minimum energy solutions, i.e., in our task those with minimum velocity. Results were consistent with hypothesis 1: execution was distributed in alignment with the solution manifold, indicating that subjects were sensitive to the probability of success. They did not show a preference for minimum execution velocity (hypothesis 2). In experiment 2, external noise was added to the subjects' performance such that execution with the original variability would no longer be successful. We tested the hypothesis that subjects can reduce their execution variability if necessary. Results showed that subjects reduced their internal variability to compensate for externally added noise. When the added noise was eliminated again subjects maintained their variability at the reduced level. These results highlighted that the internal motor noise constrains performance but it can also be decreased if necessary.

Effector Independence and Practice: Specific Left Hand Gains in Right-Handers

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The aim of this study was to investigate the effector specificity hypothesis (through bilateral transfer of learning) after an extended practice period with the non-dominant left hand. In studies focusing on the dominant right hand, an effector independent improvement is usually found after a short period of practice, which is followed by effector dependent gains after more widespread practice. However, the brain's cortical function lateralization raised the question if the same would hold true for the non-dominant left hand. Eighteen right-handed subjects completed five practice trials with the non-dominant hand (inserting 25 pins per trial) after a pre-test (PT) with both hands in the Grooved Pegboard task. After a retention test (RT1), participants performed five additional trials, followed, 2 days later, by ten trials and another retention test (RT2). The task goal was to insert all pins as quickly as possible (time was measured in seconds); knowledge of results was given on all trials and withheld on all tests. A one-way ANOVA with repeated measures was performed on pre-test and both retention tests' scores for both hands (ND: non-dominant hand; D: dominant hand). The Bonferroni post-hoc test was used to locate the differences. Results showed an effect of practice [$F(1.75, 29.75) = 22.90$, $p < 0.001$]. Differences throughout practice were detected for the non-dominant hand in all tests: RT1/ND and RT2/ND were both better than PT/ND ($p < 0.001$ in both cases), and RT2/ND was better than RT1/ND ($p < 0.01$). However, only an initial improvement was evident on the dominant hand: despite RT1/D and RT2/D were both better than PT/D (respectively, $p < 0.007$ and $p < 0.002$), no statistical differences were verified between RT1/D and RT2/D. In addition, comparisons between non-dominant and dominant hands showed that subjects had dissimilar performances with different hands at the beginning of practice: PT/ND was worse than PT/D ($p < 0.03$). The difference remained up to the first retention test: RT1/ND was also worse than RT1/D ($p < 0.03$), though there was no statistical difference in the second retention test. This result might be related to the increased performance on the non-dominant hand and to the halt in the dominant hand improvement after retention test 1. The results thus suggest a confirmation of the effector independent/effector dependent sequence of learning achievements found in studies focusing on the dominant right hand. Our findings are in line with the notion of functional integration between specialized brain areas and the dynamic characteristics of motor function lateralization.

Epistemological Basis to Development of Coordination and Motor Control

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The development of coordination and motor control brings along the learning and memory process. This contemporary perspective suffered paradigmatic influences during the history and evolution of the science of human movement. The objective of this text is to critically examine the main behavioral theoretical approaches that explain this phenomenon from the 1960s until the present. Three theoretical models based the arguments: information processing, action system, and dynamical systems theory. The behavioral approach of information processing considered coordination and control as results of the hierarchical organization of superior nervous areas towards inferior areas, represented by motor programs. In this explanation,

information is stored due to feedback and is induced by processing stages that produce control, precision and motor learning. The concept of indirect perception is based on sensations that compared to a basic on process of representation. The action system theory is explained on the domain of freedom of degrees and the contest variability through heterarchy. Internal and external constraints would limit the role of representations. The development of motor coordination would take place by pattern changes in the dynamics of the coordinative structures submitted to a control by modulation of power parameters, speed, and amplitude of pattern in sequential order. This explanation was based on an ecological approach in which direct perception and sensorial information would guide the subject to perform a skill that he learned during the experience in the environment. The approach of dynamic systems works with a model that explains the order and emergent complexity that generated motor coordination patterns during development and learning control. The cooperation among the individual parts of the motor system would represent the probability of information occurrence of each coded message, from perception to motor action, mediated by plastic memories that would determine learning, supplying neuromotor basis for the human being's behavior. Considering the examined approaches, aspects that were put as antagonistic, contradictory, and consensual with three theoretical arguments, supplied a solid epistemological base that supports the research in the development of coordination and motor control areas. They, nowadays, integrate biomechanical, behavioral molecular, and cognitive neuroscience.

The Effect of the Hypotherapy Applied to a Case of Delay in Neuropsychomotor Development When Compared with an Individual Without Alterations of a Twin Gestation

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Introduction: Neuropsychomotor development is the capability of an individual to realize increasingly complex functions since the time of uterine life. Some children have a delay in psychomotor development and need to initiate a physiotherapy program. There are different approaches to this, and one is hypotherapy, a complementary therapeutic practice with the interaction of a horse as an aid to reorganize the neuropsychomotor of patients. *Objective*: Observe the effects of hypotherapy treatment in a case of neuropsychomotor development delay. *Method*: Two children age of 1 year took part in the study, one with neuropsychomotor development delay without defined cause and her twin sister, without alteration of development, used for control and not subjected to any treatment. From December 2005 to August 2006, both children were evaluated by the Pediatric Evaluation of Disability Inventory (PEDI), an evaluation instrument that contains 197 items in the areas of self-care, mobility and social function that shows alterations in functional abilities. The intervention was performed only on the child with neuropsychomotor development delay, resulting in 48 sessions during an 8-month period. *Results*: To facilitate in understanding and to make comparisons among areas, results have been transformed to percentages and will be presented with the values of the first and second evaluation of each child, respectively, followed by the value of improvement obtained: child with neuropsychomotor development delay; self-care (11% and 15%

- increase of 36%); mobility (1.7% and 3.4% - increase of 100%); social function (6.2% and 7.7% - increase of 24%). The normal child obtained the scores in self-care (34.3% and 43.8% - increase of 26%); mobility (79.7% and 81.4% - increase of 2.1%) and social function (24.6% and 33.9% - increase of 37.8%). It is observed that in the two children, as well as in all of the areas of the PEDI, the second evaluation presented improved results, also the percentage of evolution of the values of the child with neuropsychomotor developmental delay that received hypotherapy service presented larger values of improvement than the normal child. *Discussion*: Despite several factors that exist which might have interfered in the improvement of test scores of the child with neuropsychomotor development delay, hypotherapy was used and can be a resource that propitiates benefits for the patient.

Shift of Manual Preference Resulting from Unimanual Practice in Specific and Related Manual Tasks

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Humans are the single species characterized by a well defined lateral preference for the right body side. Such a lateral preference is particularly strong in right-handers for manual skills. This feature has led to a pervasive conception of handedness as inherited, and so impermeable to environmental effects and quite stable over time. In the present investigation this assumption was tested by assessing the effect of unimanual practice on manual preference and performance. Twenty right-handed university students participated in the study. They were assigned to an experimental or to a control group. The experimental groups were provided with 100 trials of practice on a sequential finger touching task with their left hand only, while the control group remained inactive. Participants were assessed on (a) intermanual performance asymmetry, indexed by movement time to complete the whole sequence of finger movements; (b) specific manual preference for the experimental task; and (c) specific manual preference for other two sequential finger touching tasks. Assessment of preference and performance was made before, immediately after, and 30 days following (retention) the period of practice, using a 1 (always left) to 5 (always right) scale. The results showed that practice led to a significant bilateral improvement of performance, leading to a quite symmetric performance between hands. Manual preference was significantly affected by unimanual practice (Chi square = 14.77, $p < 0.001$). Before practice the experimental group was typically right-handed for the main task (M = 4.3). Immediately after practice their predominant manual preference shifted significantly toward the left hand (M = 2.3; Z = 2.66, $p < 0.01$), a profile which was not significantly different from that observed in retention (M = 2.7). The persistent shift of manual preference found for the practiced task was also observed for one of the transfer tasks, which was more similar in structure to the practiced task. No significant shift of manual preference was found in the control group. These results suggest that manual preference for specific and related motor tasks is determined by previous unimanual experiences, while performance asymmetry seems to be of minor importance in the establishment of specific manual preferences.

Effect of Visual Stimulus Velocity on the Acquisition of a Task of Tracking a Sequence of Light Stimuli

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The study investigated the effect of visual stimulus rate on the acquisition of a task of tracking a sequence of light stimuli with the aim to know the uncertainly level caused for them. A hundred and twenty male adults (X = 24.2 years; SD = 3.56) participated in this study. The experimental design involved six experimental groups: G1 – 300 ms of the inter-stimuli interval (ISI); G2 = 400 ms of ISI; G3 = 500 ms of ISI; G4 = 600 ms of ISI; G5 = 700 ms of ISI and G6 = 800 ms of ISI. The task consisted of touching six response keys in a given order performed in association with the lightening of the LEDs in a specific sequence, with the aim to recognize the pattern of this series. All groups performed 10 blocks of 60 trials; the first block, the middle block and the last one were used in the statistical tests. Global performance was evaluated by four types of response: anticipatory, correct, incorrect and omission responses. A repeated measures analysis of variance tests for multiple dependent variables (6 groups × 3 blocks) was used; in terms of the tests of hypotheses for interaction effects the results of the analysis of variance were significant to the anticipatory responses (df = 5; $F = 3.85$; $p = 0.0001$) as well as to the correct (df = 5; $F = 8.17$, $p < 0.0001$), incorrect (df = 5, $F = 3.70$, $p < 0.0001$) and omission responses (df = 5, $F = 2.46$, $p < 0.0081$). The Ryan-Einot-Gabriel-Welsch (R-E-G-W) multiple range post hoc test was used to evaluate differences among specific means. As was expected, the distinct rates of visual stimulus invoked a level of uncertainty in the system which responded with the distinct changes in the four types of responses. The ISI in the first two groups was considered very exigent, causing high level of uncertainty during the practice; in another extreme, in the last two groups, the ISI permitted the system to use all types of responses, since the first block of trials, and it was considered not very exigent. The ISI of G3 (500 ms) was one which causes uncertainty sufficient to press the system to change the performance by trying to increase the functional responses (correct and anticipatory responses) during the practice, which could attend to the aim of the task.

Principles for Learning Horizontal-Planar Arm Movements with Reversal in Individuals with Down Syndrome

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Purpose: It has been shown that with practice of single-joint movement individuals with Down syndrome changed muscle activities from co-activation to a reciprocal and triphasic patterns improving movement kinematics. During multi-joint reversal movements these individuals were unable to modulate the muscle activities and muscle torques with target distance. This study tested the hypothesis that individuals with Down syndrome are able to adopt with practice kinematics, kinetics, and

electromyography strategies to more efficiently control multi-joint reversal movements on the horizontal plane. *Participants*: Eight human individuals with Down syndrome took part in this experiment. All subjects were right-handed and between 15-30 years old. *Methods*: Kinematics of the upper arm movements with reversal, performed over three distances, was reconstructed using a motion analysis system. The muscle and interaction torques of the shoulder and elbow joint were calculated using inverse-dynamics. EMG activities of the major arm muscles were also recorded using surface electrodes. The movements were divided into four phases (acceleration and deceleration phases from initial position until the target and of the target until initial position) *Analysis*: Practice and target distances characterized the two major independent variables while the kinematics values (peak speed and movement time at the target), kinetics values (the four impulses of each of the four torques) and the integrated EMG values (four integral values for each of the four recorded muscles) comprised the dependent variables. *Results*: After training, individuals with Down syndrome did not improve the amount of muscle activities, even though they better alternated the agonist and antagonist bursts. They failed to improve the amount of the dynamic muscle torques and interaction torques at both joints. However, they improved the ratio of the shoulder to elbow dynamic torques. With practice these individuals reduced movement time, reversing the limb very quickly at the target, but did not improve movement speed. *Conclusion*: Individuals with Down syndrome can gain from practicing movements with reversal. However, even after intensive practice they failed to use some mechanical strategies that may lead to enhanced movement speed. This study showed that physical therapists play an important role in helping individuals with Down syndrome to improve motor control strategies by practice.

The Relation Between Short-Term Memory and Motor Age in Students with Age Between Seven and Ten Years Old

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This study aimed to identify alterations in the motor development and on the capacity to remember spatial movements in children attending a public school in Ribeirao Preto, São Paulo, Brazil. This is a quantitative descriptive study. The data collection was performed with 16 children, age between seven and ten years old. To evaluate the motor development and age, the scale for Motor Development (EDM) was applied, for the evaluation of capacity to remember spatial movements, that is, short-term memory, it was applied the Corsi blocks task. Results showed that 7 (75%) out of the 16 children who participated in the study obtained a score very inferior than that expected for their age, 3 (18%) children were considered inferior and only one child (6.4%) presented an average/normal score. It was observed on the Corsi blocks task that as the number of proposed digits increased the number of errors also increased. In the series of three digits, all 16 children answered correctly while in the series of six digits, all children answered wrongly and on the series of seven digits, only one child (6.3%) answered correctly. The results suggest motor skills difficulty among students between seven and ten years old, evidenced by the children's motor age being inferior to their chronological age. In addition, children

with difficulties in remembering spatial movements also had difficulties on the motor tests of spatial organization, body scheme and fine motor skills of EDM.

Development of an Assessment Protocol of Balance for Children Four, Six and Eight Years Old: A Functional Perspective

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The objective of this study was to develop an assessment of corporal balance and verify its adequacy and applicability in a sample of Brazilian children. The participants were 66 typically developing children, ages four, six and eight years old, recruited in three schools for middle class families. Each age group was composed of 22 children, 11 girls and 11 boys. The test protocol was composed of eight tasks distributed in two circuits. All tasks were scored by quantitative and qualitative criteria. The quantitative criteria were based on the time spent and the number of steps/jumps correctly executed in the corresponding items. The qualitative assessment was scored with a four point ordinal scale, based on action verbs. Results of the intraclass correlation for inter-rater and test-retest reliability were satisfactory. To compare the age groups, the non-parametric Kruskal-Wallis test was utilized, and to locate the difference between groups, the Mann-Whitney U test was used. There were significant differences between four and eight year old children in the dynamic tasks, both for quantitative and qualitative criteria. Difference in performance between four and six year old children was also observed in some of the tasks. Most differences between six and eight year old children in the balance tasks examined were not significant. It was concluded that the assessment tool showed potential for clinical use. Future studies will verify the clinical utility of the protocol for children with motor delays.

Adaptation to Change in Distance in Rapid Interceptive Tasks

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Interception of moving targets requires coupling the planned movement to an external time constraint, in this case the arrival of the target object. However, skilled action requires not only the ability to intercept objects with predictable trajectories but also the ability to adapt to unexpected target perturbations. This situation can be identified in sports such as tennis and volleyball where the players planned action must be suddenly revised based on the opponent's unexpected action. Task conditions clearly determine whether it is possible to successfully alter a pre-planned response. The experiment reported here investigated whether it was possible for participants to alter their movement amplitude when given notice at the time of movement onset. The task involved hitting moving targets (1.0/ms) which traveled from right to left via a motor-driven linear positioner. The moving

platform contained two separate targets positioned at 28 cm and 44 cm forward of the starting position of the bat. The bat was constrained to move across a slide rail perpendicular to the linear positioner. On any given trial, the task was to hit only the LED-illuminated target. The illumination of the target was either predictable (control condition) or unpredictable (perturbation condition). In the predictable condition, the same target was illuminated for the duration of the target trajectory. In the unpredictable condition, illumination swapped from one target to the other at the time of movement onset. The ratio of perturbation to control trials was 1:9 (randomly presented) with a total of 200 trials. The results showed that adaptation to the near-far perturbation condition occurred more readily than adaptation to the opposite perturbation condition (as indicated by a comparably higher hit rate and a lower temporal error). Moreover, in the unpredictable conditions the overall movement speed increased with the far-near perturbation and decreased in the near-far. These results show that adaptation can be different in accordance to the type of perturbation. (The first author had support from CAPES (Brazilian Government Agency) during the post-doctoral program at The University of Queensland.)

Motor Learning in Children and Adults: What Is Similar? What Is Different?

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Aim: To compare the acquisition of a new motor skill in children between the ages of 9 to 10 years, and healthy young adults, after one session of training. *Methods*: The task consisted of two sequences of five opposing finger movements; one of them was trained (four blocks of 600 movements each). Time of training and performance (speed and accuracy) was compared, before, right after, and 4, 7, 14 and 28 days after training between the two groups. The experimental group was composed of 20 children with mean age of 9.6 years (SD = 0.5), while the control group consisted of 20 young adults, with mean age of 26.7 years (SD = 3.77). *Results*: During the training, children performed blocks as fast as adults but showed difficulty in performing them in a specific sequence. After training, children were able to improve their performance in terms of speed and accuracy like adults do, but they were slower (ANOVA, sequence × assessment × group, [$F(15, 70) = 23.836$, $p < 0.001732$] and less accurate (ANOVA, sequence × group, [$F\ (3, 30) = 19.5451$, $p < 0.00001$] in comparison to adults. *Conclusions*: Although it could be expected that children would learn a new skill in a easier way than adults, our data does not support that idea. The findings suggest that the differences between children and adults could not be explained by differences in terms of motor execution (time to execute any sequence). It could be attributed to distinct strategies to programming movements (performing movement in a specific sequence).

Haptic Perception in Typically Developing Children

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Introduction: Development of perceptual and motor skills allows the emergence of competencies necessary for tool use. To date, tool use in children has been investigated as a sensory-motor phenomenon, rather than an action-perception coupling. Exploration and manipulation of objects allows children to learn about objects' properties, which specify their affordances. The dynamic component of haptic perception (dynamic touch) is global, exploratory and executive, and it allows the extraction of an object's invariants that inform about the object's properties. However, the development of dynamic touch in children has not yet been investigated. *Aim*: To examine haptic perception in typically developing (TD) children of different ages. *Methods*: Four wooden rods were randomly presented to TD children of three age groups: 4 (n = 8), 6 (n = 8) and 8 years old (n = 8). The rods had mass and torque equivalences but different eigenvalues; two of them were straight (not pullable) and the other two were L-shaped (pullable). The two L-shaped rods had a long or a short branch, which allowed them to work as a hook. Procedures were divided into three parts: first, children were presented to all four rods and were asked to manipulate them. Second, they were asked to manipulate the rods under a covered surface (without vision), and identify the rods that afforded pulling a toy truck filled with candies, which was attached to a string (action-perception condition). Children manipulated each rod and after their judgment, they attempted to accomplish the affordance (pulling the truck with the rods that had a hook). Finally, children were asked to move around each rod without vision and identify whether or not they had a hook (movement-perception condition). ANOVA tested the main effects experiment (n = 2), age (n = 3) rod (n = 4) and interactions on adjusted kappa index (agreement). *Results*: Significant age and condition effects, with older children and action-perception condition showing stronger agreement. Significant interaction experiment × rod (p = 0.02) was documented; straight rod in the movement-perception condition induced children to error (negative adjusted kappa). *Conclusion*: When information was used for action children made fewer mistakes. The condition (context) in which children explored objects seemed to have influenced the extraction of specifying variables (e.g., rod's eigenvalues), thus contributing to a more precise haptic perception.

Variability in the Initiation of Trunk Rotation in the Overarm Throw

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The trunk action in overarm throwing can be qualitatively divided into three levels of development characterized by the absence of rotation (L1), blocked or upper torso rotation only (L2), and differentiated rotation (L3) (Roberton, described in Haywood & Getchell, 2001, p. 148). Roberton and Konzcak (2001) highlighted that information may be lost with this classification system, and suggested the inclusion of range of motion information to rectify this. In support of Roberton and Konczak's (2001) conclusion, Stodden, Langendorfer, Fleisig and Andrews

(2006) found that the peak angular velocities seen in L2 trunk actions may begin to approximate the angular velocities of L3 performers. The goal of the present study was to examine the differences in trunk reversal actions among performers of different ability levels. Nine participants were filmed (MAC) performing five maximal effort throws. Four different strategies of trunk initiation were found: 1) lower trunk (LT) propulsive action slightly preceded that of the upper trunk (UT); 2) UT rotation slightly preceded or coincided with that of LT; 3) a long slow rise in LT rotation velocity (mean > 350 ms) before UT onset; or 4) a long slow rise in both LT and UT velocities before a rapid acceleration. The measurement of discrete temporal variables characterizing the initiation of forward rotation, attainment of peak angular velocity or the ranges of motion of the involved segments do not accurately reflect the complexity of the reversal motion at the trunk. The precise nature of this change is important with regard to the generation and transfer of energy through the system. Results are discussed in relation to alternative methods of assessing the quality of the trunk reversal action, particularly in relation to the x-factor and x-factor stretch measures used in golf (Hume, Keogh, & Reid, 2005).

Kinematics Applied to Nutcracking of Capuchin Monkeys with Different Levels of Proficiency

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Tufted capuchin monkeys (Cebus ssp) use stones spontaneously as tools to crack open nuts. Younger monkeys who are successful in this task are less proficient than more experienced monkeys. What features of this behavior are improving along the learning process? According to the action/perception perspective, a framework for studying development, variability is an important part of the process: insofar as they interact with the environment and the objects of the task, variability decreases as conditions for patterns emerge. The aim of this work was to compare the movements used by monkeys with different levels of proficiency during nutcracking to check if a decrease in variability could be detected. The subjects belong to a semifree group of tufted capuchin monkeys from Tiete Ecological Park, SP, Brazil. We collected data using four cameras (Sony HC90) (60 Hz) disposed as square vertices, around a nutcracking site. To classify the monkeys according to their proficiency level, we defined their Index of Proficiency (I*P* = n nuts cracked/n strikes). Two monkeys were compared: 1) a high expert (I*P* = 0.8, Nbouts = 19), and 2) a low expert (I*P* = 0.2, Nbouts = 16). We recorded their grasping style and scored the top position of their wrists across the strikes. The monkeys used both hands to grip the stones, with different grasping styles: while the high expert monkey held it laterally, the low expert monkey grasped the front part of the stone. We found that the high expert monkey raised his hand up to a higher spot. He also showed more variation as to how high he elevated his hand on the elevation of the stone, while the low expert monkey kept a more stable pattern. At first sight, this data does not support the

idea of decreasing variability with experience. However, the high expert monkey may be adjusting the height of the stone to the nut, so that he can reach the optimal height necessary for obtaining the best potential energy for a successful strike: the variation may be an expression of behavior flexibility, a reflection of learning. Apparently, his grip allows more precision in nutcracking. The next steps in this research will be registering the low expert monkey's improvement in expertise to check if she changes her grip and increases the height of stone elevation. Also, we will analyze their motor synergies to check if a stereotyped kinematic pattern of joint trajectories characterizes the strikes of the high expert monkeys.

Influence of therapeutic Force Fields on Visuomotor Learning

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Background: In rehabilitation, patients with motor impairments have to relearn motor control. Therapists manipulate arm movements of the patients by assisting, guiding or resisting these movements. Rehabilitation robots can manipulate the movements similarly, and simultaneously increase the training intensity for the patients and reduce the load on the therapist. In recent years, several manipulation algorithms have been implemented, like using assistive forces when deviating from the optimal trajectory, or forces which enlarge the errors to increase the awareness of the errors and accelerate adaptation. Although the effects of these manipulations on motor learning in healthy subjects are not yet fully understood, many of these manipulating forces are already in use in stroke rehabilitation. *Goal*: To increase the understanding of how dynamic force fields interact with human motor learning, we examined how different force fields affected learning of a new visuomotor task. *Methods*: We used an admittance controlled robotic device to investigate adaptation to a 30° CCW visual distortion in several dynamic environments. Fifty subjects were divided equally into five groups, with each group subjected to different force fields. Subjects trained center-out reaching movements to five different targets. Group A ("Active") group, faced no additional forces. Group P ("Passive") were moved by the robot. Groups HG ("Hard Guidance") and SG ("Soft Guidance"), were guided during movements with, respectively, high and low, error-restraining stiffnesses. Group EE ("Error Enhanced") experienced a negative stiffness that augmented movement errors. All groups were tested through catch trials on adaptation and generalization effects, and finally washout effects. *Results*: Groups A, EE and SG did adapt to the kinematic distortion. No differences between group A and EE were found, whereas group SG adapted to a lesser extent. Preceding groups also showed generalization to alternative directions. Groups P and HG did not adapt to the novel kinematic field, evidenced by the absence of "washout" effects. In active training, people adapted to novel kinematic fields and learned new visuomotor relations. Addition of forces during training did not accelerate visuomotor learning, but could slow or prevent it. *Discussion*: These results suggest that optimal visuomotor motor relearning after a stroke would be accomplished by rehabilitation programs consisting mainly of active participation of patients, in which (robotic) assistive support is minimized as soon as possible. For other rehabilitation targets such as increasing muscle tone, reach and pain relief, resistive or assistive force fields may be beneficial.

Effect of Body Orientation on Eye-Head Coordination in Preterm Twins

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Newborns are shown to be able to visually track a moving object from the first days of their lives. This ability, known as eye-head coordination, promotes the exploration of the environment as well as the acquisition of other motor skills. The aim of this study was to compare the effect of body orientations on eye-head coordination in preterm twin infants. After obtaining approval from Research Ethics Committee of the University Federal of Sao Carlos (protocol n. 0084.0.135.000-06), one preterm twin couple (gestational age: M = 32 weeks), with mean weight of 1740 g (SD = 56.57 g), and Apgar 5/8 (infant 1) and 8/9 (infant 2) in the first and fifth min, respectively, were evaluated at the first (33 days) and second (60 days) month of life. The infants were positioned in a baby chair and evaluated in three different body orientations: 1) supine, 0° from horizontal; 2) supine with slight flexion of neck; 3) and reclined, 20° from horizontal and slight flexion of neck. In each position, a card with a face drawn on it was presented at 25-30 cm from the infants' head. After having the infant stare at the card, it was moved to the front of the infant's eyes, during 2 min, with an interval of 20 s between each trial. Three-dimensional kinematical analyses examined head motion, i.e., flexion, inclination and rotation movements. Data analysis was performed by using ANOVA. The results showed no differences among the infants at the first month. At the second month, infant 2, in reclined position, showed better eye-head coordination than infant 1 with regard to flexion [$F(1,19) = 11.428$, $p = 0.003$], inclination [$F(1,19) = 7.643$, $p = 0.012$] and rotation [$F(1,19) = 5.274$, $p = 0.03$] movements. Infant 1 showed no significant differences between the first and the second month in all positions, while infant 2 improved inclination movement at the second month in reclined position [$F(1,19) = 14.693$, $p = 0.002$]. The results suggest that the twin infants showed a different course of development, although exposed to the same extrinsic constraints. Furthermore, the comprehension of how eye-head coordination progresses over age seems to be useful to detect probable delay of motor development.

Assessment of Motor Development in Typically-Developing and Down Syndrome Infants by Using the "Alberta Infant Motor Scale"

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The purpose of this longitudinal study is to characterize and compare motor development in typically-developing and Down syndrome infants aged 3-7 months by using the Alberta Infant Motor Scale (AIMS). The control group was composed of four healthy typically-developing infants (gestational age, M = 38.6 weeks, SD = 0.65 weeks). The experimental group comprised four healthy infants with Down syndrome, two born full-term (gestational age, M = 38.5 weeks, SD = 0.5 weeks), and two born preterm (gestational age, M = 35 weeks, SD = 0), who were evaluated at their corrected age. The infants from the experimental group received physical therapy treatment from the third month onwards. After obtaining parental consent as well as approval from the Research Ethics Committee (protocol n.

079/2006) of the University Federal of São Carlos, the infants were evaluated from 3 to 7 months through AIMS. This scale evaluates infant motor development in four different positions: supine, prone, sitting, and standing. ANOVA for repeated measures was used to find differences between control and experimental groups, among ages, and among positions. The significance level was $p < 0.05$. The results showed differences between groups [$F(1,3) = 20.512$; $p = 0.020$], ages [$F(4,12) = 13.910$; $p \leq 0.001$], and positions [$F(3,3) = 19.927$; $p = 0.17$]. The control group showed higher AIMS scores. However, there were no significant differences between groups with regard to the gain of scores over age [$F(4,12) = 1.563$; $p = 0.247$]. The contrast test indicated that infants from both experimental and control groups showed increasing linear rhythm of motor acquisition over age ($p = 0.024$). There were no differences between supine and prone positions for both groups in all months studied. For sitting and standing positions, the experimental group showed higher AIMS scores. The results suggest that typically-developing infants showed improved motor development in comparison with Down syndrome infants, especially in sitting and standing positions, which require greater postural control. Additionally, Down syndrome infants showed increasing linear rhythm of motor acquisition over age, similarly to typically-developing infants.

Effects of Visual Manipulation in Children's Postural Control

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The maintenance of upright stance is a challenging task and demands a complex relationship between sensory information and motor action. Developmental differences in postural control have been observed during the first decade of life. Children oscillate with larger amplitude than adults during the maintenance of upright stance and are more influenced in situations of sensory conflict, showing also larger body sway amplitude than adults. Therefore, the aim of this study was to examine the influence of a discreet manipulation of visual information in children and adults. Ten eight-year-old, ten twelve-year-old children and eight adults were asked to maintain the upright stance inside a moving room that discretely oscillated back or forward with amplitude of 2.6 cm and average velocity of 1.3 cm/s. Participant trunk's sway and moving room displacement, in the antero-posterior direction were obtained through IRED markers. Dependent variables were latency to respond to the movement of the moving room, amplitude and time reversal of body sway due to the influence of the moving room, peak velocity and time of peak velocity of body sway after the movement of the moving room. Results revealed that children showed larger body sway amplitude than adults and 8-year-olds larger body sway amplitude than 12-year-old children. Latency was the same for all groups and time of body sway reversal was longer for 8-year-olds than for 12-year-old children and adults. Children showed higher peak velocity of body sway than adults and 8-year-old children showed higher peak velocity than 12-year-old children. Finally, the time of peak velocity was longer for 8-year-olds than 12-year-old children and adults. These findings suggest that children and adults have the same sensibility in detecting the visual stimulus, provided by the movement of the moving room. However, young children are more influenced by this sensory manipulation indicating that they might have more difficulties in estimating the dynamics of body oscillation.

Therefore, young children might need longer time or a larger magnitude of sensory stimulus related to the dynamics of body sway, in this case body velocity, to resolve the perturbing situation and recover the postural orientation.

How Old Are Children When They Can Perform a Visuomotor Dual–Task?

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The ability to perform simultaneous activities develops progressively in childhood until total complexity is reached in adults. However, the development of this ability, which involves divided attention, has not been described in the literature so far. *Objective*: To verify the ability and performance of 6-to-12-year-old children in a dual-task, which consists of a visual task and motor task. *Method*: Nineteen children with good health, normal or corrected vision, were divided into two groups: G1: 6-8 years old and G2: 9-12 years old. The experiment was divided into three parts: training, session 1 and session 2. In training session and session 1, the children first alternated steps from the ground to a 10 cm platform for 2 min. After that, they performed the visual task. They stood 50 cm from a computer screen and had to verbally inform the examiner which stimulus (bus or truck) appeared in the center and which stimulus (bus or truck) appeared in the periphery of the screen in one of eight possible peripheric positions. The answers were typed by the examiner on a computer keyboard and analyzed by the computer (MEL2 software). In session 2, both visual and motor tasks were performed simultaneously. Between sessions 1 and 2, the children were asked to throw 20 balls inside a basket (distractor task). *Results*: The ANOVA evidenced that G1 was faster than G2 at the motor task: 6-8-year-old children performed a greater number of steps per second ($p < 0.0566$). G1 was less accurate at the visual task ($p < 0.0714$). *Conclusion*: We can infer that 9-12-year-old children presented better performance on the proposed task than 6-8-year-old children, who could not execute the tasks simultaneously, performing only the motor task; 9-12-year-old children could perform the dual–task (visual and motor task simultaneously), suggesting that the ability to divide attention in this kind of task possibly develops in this period of life.

Effects of Practice Schedule on Motor Learning in Poststroke Patients

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The purpose of this study is to investigate the practice schedule effect in poststroke patients. *Method*: Seventeen poststroke subjects (experimental group - E) and 17 healthy controls (C), age 36-86 years, of both genders, executed a coincident timing task. All the subjects were submitted to a coincident timing task. Nine (9) subjects of each group accomplished constant practice (C) and eight (8) aleatory (A). The Acquisition phase (A) was constituted by 30 trials, with a speed of 3 (mph) for constant group and 2, 3 and 5 (mph) for aleatory group. The following phases: Transfer for similar ability (T), Retention of the short term learning (R1), after 15

minutes, and long term Retention (R2), after 3 days, held 10 trials each, at two different speeds 1 and 4 (mph). To compare intra and intergroup situations, Friedman, Wilcoxon, Kruskal-Wallis and Mann-Whitney tests were used, considering a significance level of 0.05 (5%). Each group was individually analyzed (EC, EA, CC, CA) during the 4 (four) phases (A, T, R1 and R2) and, only in constant practice, statistically significant differences occurred in performance, as much in the control group ($p = 0.009$) as in the experimental one ($p = 0.012$). It was possible to note that independently of practice schedule or speed, the experimental group showed poorer performance in all the tests. The experimental group showed greater difficulty in slow speed and the aleatory stroke group showed better transference when compared with constant practice stroke patients ($p = 0.007$). Those results indicate that there is a difference in motor learning in post-stroke patients, when compared with healthy people. However, in spite of the impaired mechanisms, there is motor learning after stroke. But, when compared to a healthy group, a stroke patient seems to be more sensitive in the transference phase at a slower stimulus speed, especially with constant practice. The speed might be relevant to performance, because the experimental group showed difficulty in performing the task at slow speed. The EA group showed better performance in transference when compared to EC ($p = 0.007$). In this way, there is some evidence that aleatory practice, when compared with constant practice for stroke patients in a timing task, facilitates transference in motor learning. Otherwise, the relevance in this topic associated with absence of more studies in this area brings the necessity of certain caution in analysis. Therefore, future studies must be designed and followed to allow continuity to the investigation.

Effect of Increasing Frequency on Stability of Relative Phase: Constraints Imposed with Asymmetric Bimanual Coordination

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The purpose of this article is to investigate the effect of increasing frequency on stability of asymmetric bimanual coordination relative phase and determination of constraints which imposed with. Two experimental groups include in-phase and anti-phase imposed on increasing frequency from 1 to 3 Hz in five steps. Results indicated that anti-phase group tended to be done in in-phase with increasing frequency. With respect to the asymmetric pattern of coordination that is done in two different axes, it may be concluded that same-directional could not be the essential constraint. Since two groups were stable in in-phase that involving activation of the same muscle groups; therefore homologous muscles activation is dominant constraint in asymmetric bimanual coordination patterns.

The Effect of Attentional and Motor Demands on Motor Overflow Production in Older Adults

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The purpose of this study was to systematically investigate how attentional and motor demands influence motor overflow production in both young adults and healthy older adults. Motor overflow is involuntary muscle activity that may coincide with voluntary movement and is thought to increase with old age. Seventeen young adults, aged 18-35, and 17 older adults, aged 60-80 years, performed a finger pressing task and exerted a percentage of their maximal force output with one hand while overflow was recorded in the passive hand. Required target force output was either 33% or 66% of maximal force and for half the trials was performed with the participants' non-dominant hand. Attention was manipulated by presenting a tactile stimulus to one or both hands for certain trials. Results indicated that older adults exhibited greater overflow compared to their younger counterparts. Although both age groups displayed greater overflow at the lower target force, this effect was exacerbated in older adults. Furthermore, overflow in older adults, but not young adults, was greater when attention was directed to one or both hands during task performance. No significant intermanual asymmetry in overflow production was found for either age group. Importantly, task performance measures suggested that both age groups were able to effectively perform the task, although older adults were significantly more variable. When attention and motor demands were imposed there was greater variability in both task performance and level of overflow production. Collectively, the increase in motor overflow in old age has been interpreted as evidence of possible bilateral cortical activation which may be influenced by increased task demands. In order to compensate for age-related brain deterioration and perform comparably to younger adults, older adults may recruit an increased cortical network of brain regions to meet task demands.

Are Age-Related Differences in Tremor Related to Cardioballistics?

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Physiological tremor (PT), the involuntary rhythmic oscillation of a limb, results from the interaction of neural and mechanical processes. Traditionally, it is maintained that there are alterations in PT with advanced age. The causes underlying the age-related changes in tremor remain to be elucidated. Of the multitude of processes that contribute to tremor genesis, this investigation examines age-related differences in cardioballistic impulse (CBI). CBI refers to the mechanical perturbation to the body resulting from the contraction of the heart and subsequent ejection of blood into the vascular system. In order to address this question, PT was recorded by attaching a uniaxial accelerometer to the dominant index finger of young (19-29 years old) normotensive, old (65+ yr) normotenisive and old hypertensive subjects. Resting tremor was recorded while the entire arm, hand and fingers supported. Postural tremor was recorded with the index finger extended, the remaining fingers forming a loose fist and the hand and forearm supported. Beat to beat blood pressure in the middle finger was simultaneously recorded. Frequency and coherence analysis

were used to quantify the influence of cardioballistic impulse on PT. Overall, there was no group difference in tremor amplitude. Significant coupling between blood pressure oscillations and tremor was observed in all groups and postures. Coupling was greatest in the resting tremor condition. Additionally, both old age groups had stronger coupling than the young group, but only in the rest condition. The findings are supportive of the role of cardioballistic impulse in tremor genesis. However, there is no evidence that age-related changes in tremor result from a change in the contribution of cardioballistic impulse.

Age-Related Changes in Posture-Leg Movement Coordination During Rhythmic Unipedal Stepping

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Introduction: During rhythmic stepping, the body center of mass (CM) must reverse direction prior to limb liftoff. This postural adjustment serves to unweight the upcoming stepping leg. Given that aging affects both posture and movement, it is surprising that relatively little is known about the age-related changes in the coordination between posture and locomotion. Lateral rhythmic unipedal stepping performed across a range of frequencies is examined here to identify the effect aging has on the coordination between posture and stepping. *Method*: Seven young adult females (mean, 24 years) were height matched with 7 older adult females (mean, 71 years). Subjects were instructed to rhythmically step a comfortable distance to the side and return to the beat of a metronome using their dominant (right) leg. Pacing began at 1 Hz, progressed to 2.8 Hz and returned to 1 Hz in 0.6 Hz intervals. Six Qualisys motion capture units were used to determine lateral step timing using a toe marker. Body CM was calculated using an 8-segment model to establish time when the CM reversed direction representing the necessary postural prerequisite for stepping. One-way repeated measures ANOVA was performed to test the effects of age and frequency on posture-stepping coordination (CM reversal time – step onset time/step period). *Results*: There was a significant effect of age on coordination [$F(1,12) = 5.51$, $p = 0.037$]. On average, older adults shifted their CM back towards the stance limb earlier relative to step onset given a particular step period (which is dictated by frequency) across frequencies and most notably the faster pacing frequencies. A non-significant frequency effect and age × frequency interaction demonstrates subjects maintained a relatively constant phase relationship across frequencies. *Conclusion*: The results are consistent with the notion that postural adjustments during locomotion are under the influence of the stepping limb, particularly its current state. Age-related changes to postural (CM) and stepping motions separately (i.e., less postural motion, maintained weight bearing on the support limb, and smaller lateral steps—to be submitted for publication), likely serve to maintain a posture-stepping coordination conducive to task completion and perhaps stability/safety maintenance during paced rhythmic stepping. It appears the typically-aging movement control system exhibits a functional adaptive capacity to meet challenges associated with time-critical stepping.

Age-Related Declines in the Perception of Upper Limb Movement and Grasp Force

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The ability to accurately control grasp force and limb position, critical in performing daily living tasks, is thought to rely heavily on somatosensory feedback. While age-related changes in upper limb motor function are well established, much less is known regarding changes in proprioceptive ability across the lifespan. This study examines the effects of age, task and hand preference on the performance of two sensorimotor tasks: perception of wrist movement and force grasp matching. Ten young adults (mean age = 21 ± 1.9 years) and ten elderly (mean age = 78 ± 6.4 years) who were all healthy, right handed individuals participated in this study. Perception of wrist movement was examined in the absence of vision using a manipulandum and a servo-motor to passively displace the wrist at 0.5 deg/s into either flexion or extension. Participants indicated perception of movement by pressing a button with the opposite hand. The degree of wrist displacement at the time of movement perception was used to determine the movement threshold. Instrumented grasp devices were used to measure grasp force while participants performed three force matching tasks at 20% of their perceived maximum grasp force of the reference limb. In the Ipsilateral (IR) and Contralateral Remembered (CR) conditions, participants matched the reference force with the same hand or opposite hand using memory-based information. In the Contralateral Concurrent (CC) condition, participants matched the reference force with the opposite hand while the reference force was maintained. Mean movement threshold was significantly greater ($p < 0.001$) in the elderly group (2.4 deg) compared to the young (1.2 deg). No asymmetries were seen between the right and left hands or between flexion and extension direction in either group. Force matching error across all conditions (IR, CR, CC) was worse in elderly than young ($p < 0.001$). In the elderly group, right compared to left hand matching was worse ($p = 0.05$). These differences were most pronounced in the contralateral conditions where matching was performed by the opposite hand (CC: $p = 0.007$ and CR: $p = 0.05$). This study demonstrates that perception of upper limb movement and grasp force declines with age. Right-left differences in force matching ability, particularly in tasks requiring interhemispheric transfer of force information, support age-related asymmetries in callosal function (Jeeves & Moes, 1996).

Practice and End-Point Accuracy with the Left and Right Hands of Old Adults

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Old adults often exhibit greater motor output variability and a reduced ability to perform accurate movements compared with young adults. The decrements in fine motor skills observed in hand muscles may be compounded by hemispheric differences in the adaptations that occur with aging. According to the right-hemisphere aging model, the decline in motor performance may be greater for muscles

controlled by the non-dominant right-hemisphere in right-handed individuals. The aim was to quantify the age-related differences in end-point accuracy of the left and right hands. Young and old adults performed rapid, goal-directed isometric contractions with a hand muscle to match the peak of a force-time trajectory to a target displayed on a monitor. The target required subjects to exert an abduction force with the index finger that was 25% of maximum in 150 ms. The old adults were less accurate than the young adults and they exhibited greater end-point error with the left hand compared with the right hand on Day 1, but not on Days 2 and 3. EMG activity was recorded from the agonist and antagonist muscles on Days 2 and 3; the amplitude was similar between hands for both age groups, however the old adults exhibited greater timing variability for the agonist muscle compared with young adults. These findings indicate that given sufficient practice there was no difference in end-point accuracy between the left and right hands of right-handed old adults, but that the old adults were less accurate than the young adults. These findings are not consistent with right-hemisphere aging models and the prediction of an asymmetric decline in motor performance for the left hand of old adults. (Supported by NIA AG09000 to RME.)

Thoracic Kyphosis Degree, Trunk Muscle Strength and Proprioception: A Comparison in Healthy and Osteoporotic Elderly Women

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Introduction: Increased thoracic kyphosis is one of the most disfiguring types of damage in osteoporotic people and it is suggested that its development is related to a greater number of vertebral fractures, decreased back muscle strength and a decline of proprioceptive information. However, these influences are not clearly understood. In order to progress our understanding of the physical sequels in osteoporotic people, this study had two aims: the first was to compare physical characteristics, including thoracic kyphosis degree, strength of the trunk flexor and extensor muscles and proprioception in elderly healthy and osteoporotic women. The second aim was to investigate the possible correlations among BMD, kyphosis thoracic degree, trunk muscles peak torque and proprioception. *Methods*: A total of 20 volunteers, over 60 years of age were divided into two groups (10 volunteers each): healthy elderly women and osteoporotic women. A densitometer was used to measure the BMD of the lumbar spine (L2 to L4). Radiographs of the thoracic spine were taken to determine the number of fractures and the thoracic kyphosis degree (using Cobb angle). Trunk extensor and flexor muscle torque and trunk proprioception were measured through an isokinetic dynamometer. *Statistical Analysis*: Data were expressed as mean and SD. Differences in physical characteristics were determined with Student's *t*-test for unpaired data. Correlations were assessed using Pearson's correlation coefficients. Probability values less than 0.05 were considered statistically significant. *Results*: Osteoporotic women demonstrated an increased kyphosis thoracic degree and a decreased trunk extensor muscle strength. No differences in proprioception level and in trunk flexor muscle strength between the groups were found. Moreover, it was demonstrated that BMD had a negative correlation to the thoracic kyphosis degree ($r = 0.36$; $p = 0.022$) and a positive correlation to the

extensor muscle strength (r = 0.51; p = 0.001). No correlation was found between BMD and proprioception (r = 0.23; p = 0.57). Kyphosis degree showed a negative correlation to extensor muscle strength (r = 0.66; p = 0.00003) and proprioception (r = 0.45; p = 0.004). *Conclusion*: The present study suggests that osteoporosis leads to a significant decrease in trunk extensor muscle strength and an increase in kyphosis thoracic degree. Additionally, it seems that lower BMD cause an increase in kyphosis degree and a decrease in trunk muscle strength and proprioception. We also suggest that the decrease of the extensor muscle strength can be a factor that contributes to the increase of the kyphosis thoracic degree.

Dizziness in Community-Dwelling Elderly Aged 80 and Over Living in São Paulo: A Multidimensional Functional Assessment

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Dizziness is a common complaint in old age population and when associated with instability can cause falls and functional decline which compromises their quality of life. The very old tend to be frailer and have a higher prevalence of comorbidities. Despite that, dizziness is often neglected as a major concern in multidimensional assessments addressing the geriatric population. *Objective*: Determine the prevalence of dizziness among an old old population, identifying the association between dizziness and socio-demographic, clinical, functional, psycho-cognitive and quality of life data and to establish the correlation between dizziness complaint, intensity and age, functional capacity, cognitive decline, mobility and depression. An exploratory cross-sectional study was conducted with 61 old subjects aged 80 and over, of both genders, living in the coverage area of Centro de Referência do Idoso (CRI), the east side of São Paulo city. A multidimensional questionnaire was used, covering 15 sections. The outcome variable used was the complaint of dizziness in the previous 12 months and the intensity of dizziness was measured by the Dizziness Analogical Scale. The main instruments used were the BOMFAQ, Mini Mental State Examination (MMSE), Geriatric Depression Scale (GDS), Timed up and Go test, WHOQL-bref. A descriptive statistical analysis was performed comprising frequencies, mean and standard deviation for quantitative data and inferential analysis through the Qui-Squared test or Fisher's test and the correlation through Pearson's correlation test and Spearman test. The significance level adopted was $p < 0.05$. SPSS version 10.0 was used to analyze data. *Results*: The mean age was 84.25 ± 2.98 SD. The prevalence of dizziness was 65.6% of whom 64.1% referred to balance disturbance and instability during gait. Among the socio-demographical data, personal income showed a significant statistical association (p = 0.007). The clinical variables that shows independent association with dizziness was chronic venous insufficiency (p = 0.041) and pain (p = 0.031). There was no significant association with functional and psycho-cognitive variables. The intensity of dizziness showed moderate correlation with cognitive function (r = -0.292; p = 0.071). *Conclusion*: Dizziness is a frequent complaint among very old adults despite the fact that relevant factors pointed out by the literature were not identified as significantly associated in this study.

Attending to the Preferred and to the Non-Preferred Hand in Complex Bimanual Task

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Bimanual coordination is required to accomplish motor actions in many of our everyday tasks. In such bimanual actions, the two hands play quite different roles, whereas the non-dominant hand generally holds an object, the dominant hand acts upon it. Furthermore, the dominant hand leads the task and is more precise than the non-dominant hand. It has been argued that the superior performance of the dominant hand is due to the visual attention on the dominant hand. The aim of the present study was to examine the effect of directing visual attention to one of the hands during the performance of a bimanual task as a function of handedness and task complexity. Ten right- and eight left-handed adults participated in this study. The bimanual task required participants to tap continuously with two styluses on a transparent glass surface (i.e., a digitizing tablet). The tapping task required participants to tap on specific target areas (squares of 2 x 2 cm) according to a rhythm. The tapping conditions were: 1:1, 2:1, 3:1 and 3:2. The first and second digits refer to the number of targets aimed by the preferred hand and by the non-preferred hand, respectively. A metronome timed the first 5 s of the 20 s trial. The direction of attention was: to the right hand, to the left hand and free. The dependent variables were the spatial and temporal errors. As expected, the results indicated that the easiest tasks (1:1 and 2:1) were performed with less spatial [$F(3,48) = 27$, $p < 0.5$] and temporal [$F(3,48) = 32$, $p < 0.5$] errors compared with that of more complex tasks (3:1 and 3:2). Right- and left-handed subjects showed similar level of spatial [$F(1,16) = 0.57$, $p > 0.5$] and temporal errors [$F(1,16) = 1.1$, $p > 0.5$]. In terms of the spatial error, ANOVA showed significant difference in the interaction between Hand and Attention [$F(2,32) = 638$, $p < 0.5$] and the post-hoc test showed that independently of hand, spatial errors for the non-attended hand were higher than that for the attended hand. Also independently of hand, there was no difference in spatial error between the attended preferred and non-preferred hand. In addition, the non-attended preferred hand showed higher error score compared with the non-attended non-preferred hand. In sum, the results for the present study showed that the preferred hand depends more on the allocation of visual attention than the non-preferred hand during bimanual coordination timed-tasks.

Prevalence of Falls in Very Old Community Dwelling Elders

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Falls are a major problem in the elderly, causing injuries, psychological difficulties, social isolation, impairing functional capacity and quality of life. Among the old population who lives in the community, about 35% to 40% fall each year. Falling is a multifactoral problem due to both extrinsic and intrinsic risk factors, but usually

a combination of factors is responsible. Prevention or reduction of falls and fall-related injuries would be a significant contribution to the health and well-being of elderly persons and could potentially result in reduced utilization of health care resources and a substantial savings in related costs. *Objective*: To investigate the association of falls in the last year with functional capacity, psycho-cognitive state, social-demographical data, quality of life data and depression. *Methods*: An exploratory cross-sectional study was conducted with 61 old subjects aged 80 and over, of both genders, living in the coverage area of Centro de Referência do Idoso (CRI), east side of São Paulo city. A multidimensional questionnaire was used, covering 15 sections. The outcome variable used was the complaint of dizziness in the previous 12 months and the intensity of dizziness was measured by the Dizziness Analogical Scale. The main instruments used were the BOMFAQ, Mini Mental State Examination (MMSE), Geriatric Depression Scale (GDS), Timed Up and Go test, WHOQL-bref. A descriptive statistical analysis was performed computing frequencies, mean and standard deviation for quantitative data and inferential analysis through the Chi-squared test or Fisher's test and the correlation through Pearson's correlation test and Spearman test. The significance level adopted was $p < 0.05$. SPSS version 10.0 was used to analyze data. *Results*: 33.3% of old subjects had a history of falls in the last year. Most fall events were in the morning (42.1%), by a propulsion mechanism (52.2%) and took place in the bathroom (38.1%). The most frequent circumstance of falls was tripping (42.1%). Among clinical variables high blood pressure ($p = 0.013$) showed a significant statistical association. Among the functional ones, the difficulty of lying down and getting up from bed ($p = 0.016$), as well as ADL impairment ($p = 0.037$) showed significant statistical association with falls in the previous year. There was no significant association among history of falls and socio- demographical, psycho-cognitive, and other clinical variables. *Conclusion*: There was an association between history of falls and functional capacity, in particularly the activity of lying down and getting up from bed as well as with high blood pressure.

Structural Learning in Visuomotor Tasks with Randomly Changing Task Parameters

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When we learn to handle a new object (e.g., to ride a bike) we learn to extract relevant control variables of the task and we learn how these relevant variables are related to each other. From a theoretical point of view, this adaptive control problem consists of a "structural" and a "parametric" learning problem. In terms of sensorimotor learning, structural learning means acquiring a novel motor skill (e.g., learning how to ride a bike from scratch), whereas parametric learning presupposes an idea of the task structure and adjusting the relevant movement parameters only (e.g., changing from mountain bike to racing bike). Once the structure is known, adaptation can occur on a submanifold of the sensorimotor space. We conducted a

set of sensorimotor learning experiments to differentiate between the phenomena of structural learning and parametric learning. The basic idea is to expose human subjects to a task with a fixed structure which can have different parameterizations. Importantly the parameters for the task change randomly between blocks of trials making the task impossible to learn, although it is possible for subjects to learn the structure which remains fixed over the trials. In a first experiment, we exposed subjects to hand-cursor rotations in a planar center-out task where the rotation angle changed randomly over trials. Although subjects learned nothing on average, we observed a significant facilitation of learning in a subsequent learning block with a fixed rotation angle as compared to subjects that did not undergo a pre-exposure with random rotations. In a second experiment, we exposed subjects to either randomly changing shearing or randomly changing rotations on a trial-by-trial basis. We interspersed fixed rotation catch trials in both groups. We found that subjects react to identical rotation catch trials differently depending on whether the learning context was either rotations or shearings. In a third experiment we exposed subjects to randomly varying 3D rotations with two different rotation axes. Also here we found facilitation in catch trials with the same rotation axis as opposed to catch trials with a different axis. Our results suggest that subjects learn to extract structural relationships between task-specific control variables. (Supported by BIF, BMBF 01GQ0420, SENSOPAC IST-2005-028056, Wellcome Trust.)

Motor Control Deficit of Pre-Term Born Children Observed at 30 Days of Age

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Introduction: Scientific evidence indicates that pre-term children present a higher risk than term children for impairment of motor development, this impairment being associated with an inadequate maturation of the central nervous system. *Objective*: To investigate the motor control of pre-term and term born children at 30 days of age. *Methods*: This study compared the motor control performance of 45 term born infants (gestational age 38.5 weeks) with 27 pre-term ones (gestational age 34.5 weeks), when they completed 30 days of life. The evaluation of the motor control of each child was made by using the Bayley Scales of Infant Development (the part referring to the first 30 days, with 18 items). A motion picture of each child was also made during the Bayley evaluation in order to check the data afterwards. The proportion of children performing adequately in each item was determined. A Chi-square test was used for comparisons between the groups. Null hypothesis was rejected when $p = 0.05$. *Results*: Pre-term children performed lower than term children in three out the 18 items evaluated. 1) "Hold head erect for 3 seconds": Pre-term 11/27 (41%); Term 29/45 (64%) ($p = 0.05$). 2) "Adjust head to ventral suspension": Pre-term 4/27 (15%); Term 17/45 (38%) ($p < 0.038$). 3) "Elevates self by arms": Pre-term 8/27 (30%); Term 37/45 (82%) ($p < 0.001$). The proportion of adequacy of the items "Hold head erect and steady for 15 seconds" and "Lifts

head" was low in both groups: Pre-term 1/27 (4%);Term 6/45 (13%) ($p = 0.182$) and Pre-term 0/27 (0%); Term 3/45 (6%) ($p = 0.178$), respectively, for these two items. *Conclusions*: Pre-term children born with 34.5 weeks of gestational age compared to term children, show a delay in motor control development at the end of the first month of life, concerning cervical control for a very short period as well as for cervical rectification reaction. However this does not occur when the control mechanisms become more complex, being low performed both for pre-term and term born children. (Funding provided by Conselho Nacional Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Process nº 403439/2004-3.)

Reaching and Grasping

The Nervous System Independently Controls Motion and Force

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When manipulating objects, we must control our hand motion as well as the interaction forces that arise from contact with the environment. At the level of musculoskeletal biomechanics, motions and forces are coupled by intrinsic limb impedance. However, it has yet to be established whether at the neural level the control of motion and force are coupled or independent. Here we provide evidence for the existence of independent neural controllers for arm motion and interaction forces. This evidence is offered by transcranial magnetic stimulation (TMS) of posterior parietal cortex (PPC) resulting in the differential disruption of the control of motion but not of force. We designed three experimental conditions where force and position control tasks appeared in combination or separately. Accordingly, our experiment consisted of three blocks: Combined, Force, and Motion. During the Combined block subjects applied force to the handle of the manipulandum in a leftward direction as it was moved to center out positions along a smooth trajectory. This block required the simultaneous control of motion and force. During the Force block subjects maintained an applied force as the manipulandum moved along a very slow constant velocity profile in which inertial effects were negligible. In this condition, the quality of force control was assessed by quantifying the ability of the subjects to maintain constant force vectors at different arm configurations. In the Motion block subjects were asked to track a predetermined movement trajectory. In order to compare performance in this and in the other tasks, subjects were required to track a predictable motion of the manipulandum while maintaining contact with it. A perfect position controller would produce perfect tracking, thus resulting in zero interaction force between the subject and the manipulandum. Deviation from zero force was attributed to errors in the ability of the subject to track the desired trajectory. Single pulse TMS was applied to left PPC during all blocks after learning. We found (a) that TMS stimulation results in disruption of performance during the Combined and Motion blocks, but not the Force Block. Furthermore, (b) at the

end of learning, a simple summation of forces from the Motion block and the Force block describe 80-97% of the variability of forces applied in the Combined block. These results are consistent with the presence, after learning, of independent force and motion controllers. They also suggest that PPC is critical to the neural control of hand motion but not of interaction force.

Influence of Body Orientation on Kinematic Parameters of Infant's Reaching

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The aim of this longitudinal study was to verify the effect of seated and supine positions on spatio-temporal parameters of reaching in 4-6-month-old infants. The main attribution is the supine position demands higher muscular torque at the beginning of reach, as the weight force vector position is farther from the longitudinal shoulder axis. While in seated position, the weight force vector position is closed to the longitudinal shoulder axis. However, it is not clear if seated position can improve reaching movement in young infants in relation to kinematic parameters of reaching. Four healthy infants were selected from health centers after evaluating their medical records. The infants were observed during reaching trials at 4, 5 and 6-months-old. After positioned in a baby chair, a toy was offered at the shoulders height, and arm's length. After each reach, the toy was taken away carefully and presented again for a 2-min period. The evaluation was performed in the supine (0°) and seated (70°) positions, at pseudorandom sequence. The whole experimental phase was filmed using three digital cameras (60 Hz). A total of 235 reaches were analyzed by using the 3D movement reconstruction (Dvideow), and the dependent variables were calculated using the Matlab program. Chi-square, Mann-Whitney and Kruskal-Wallis tests were applied for variables: frequency, duration (s), straightness index, deceleration time (s), and mean velocity (m/s). The significance level used was $p < 0.017$, which was corrected for the number of comparisons. Our results showed that frequency of reaching ($X2(2) = 12.209$; $p = 0.002$) and straightness index ($H(2) = 17.492$; $p < 0.01$) increased over age. The frequency of reaches was higher ($X2(1) = 7.896$; $p = 0.005$) in seated than supine position. Significant differences between the positions were observed at 4 months, when the duration ($U(1) = 179.5$; $p = 0.001$) and deceleration time ($U(1) = 214.5$; $p = 0.009$) decreased in the seated position. There were no significant differences at 5 and 6 months. After experience and improvement of motor abilities to control their arms, infants can solve the problems related to instability of arms in the supine position. Thus, the results suggest that young infants are able to change kinematical parameters of reaching to adapt themselves to intrinsic and extrinsic constraints, e.g., age and position. (Support: Capes.)

Hemispheric Specialization During Visually-Mediated Response Modifications

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Introduction: Motor lateralization has previously been attributed to specialization of the left and right hemispheres for open- and closed-loop processing, respectively. We have recently proposed a more specific hypothesis of lateralization that attributes control of limb impedance/steady-state position to right hemisphere processes and control of intersegmental coordination to left hemisphere processes. This hypothesis was based on reaching studies, for which the contributions of open- and closed-loop control had not been experimentally dissociated. The purpose of this study is to determine whether left- and right-hemisphere-damaged patients will show differences in the quality of visually-mediated corrections to target perturbations. We hypothesize that left-hemisphere-damaged patients will show deficits in intersegmental coordination during corrections, while right-hemisphere-damaged patients will show preserved coordination with errors in the accuracy of final steady-state position. We expect that these differences will reflect hemispheric specializations for the associated control processes, regardless of the feedback-dependent nature of our task. *Methods*: Eight right-handed hemiparetic stroke (4 left damage, 4 right damage) patients and 8 right-handed age-matched control subjects were instructed to reach 16 cm to one of three ipsilateral targets located 40°, 0°, or -40° from the start position. Control subjects used their right or left arms, and patients used their ipsilesional arm. During perturbation trials, the target location unexpectedly changed ± 40° at movement initiation in order to test response modification. Each subject performed 234 total trials without visual feedback, with pseudorandom "jump" trials occurring every six trials. *Results*: For left-hemisphere-damaged patients, corrective responses occurred earlier in the movement and were primarily driven by changes in shoulder joint torque. However, these responses were poorly executed due to inappropriate coordination of elbow muscle torques with interaction torques produced by the shoulder motion. Right-hemisphere-damaged patients showed relative delays in response initiation compared to other subjects. These corrections were straight and coordinated, but produced errors in final position. *Conclusion*: Our results support the hypothesis of left hemisphere specialization for intersegmental coordination. While both patient groups showed impairments in the final accuracy, it is likely that the position deficits in left hemisphere patients are attributed to impairments in multijoint coordination. This interpretation is supported by our previous research in which such patients made accurate single-joint movements. However, relative delays in correction for right-hemisphere-damaged patients do not preclude the more general hypothesis of right hemisphere specialization for closed-loop error correction processes.

Body Orientations and Experience Affect Proximal and Distal Adjustments of Infants' Reaching

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Although the effect of different body orientations on infants' reaching movements have been widely studied, little work has addressed this essay taking into account the skill level and experience of the reachers. This longitudinal study verified the influence of intrinsic (skill level and experience) and extrinsic (body orientations) constraints on infants' reaching movements. After obtaining approval from Research Ethics Committee of the University Federal of Sao Carlos, ten 4-6-month-old infants, classified as less- ($n = 6$) or more-skilled ($n = 4$) reachers, were evaluated according to their level of experience both at the acquisition of reaching and after one month of spontaneous practice. Proximal (uni or bimanual reaches) and distal (open, semi-open or closed hands) adjustments, hand position in the beginning of the movement (close to or apart from the body), and grasping were analyzed when reaching in supine (0°), reclined (45°) and seated (70°) positions. The results indicated that frequency of unimanual reaches was higher for less-skilled reachers in seated position at reaching acquisition ($X2(1) = 6.737$; $p = 0.009$), as well as in supine ($X2(1) = 6.081$; $p = 0.014$) and seated ($X2(1) = 7.714$; $p = 0.005$) after practice. Predominance of unimanual reaches was observed in all body orientations for more-skilled reachers both at the acquisition and after practice. Less- and more-skilled reachers performed more reaches with hands semi-open in all body orientations, except for the less-skilled ones in reclined position after practice ($X2(1) = 2.286$; $p = 0.131$). Less-skilled reachers performed more reaches with hands close to the body at reaching acquisition in reclined ($X2(1) = 8$; $p = 0.005$) and seated ($X2(1) = 8.526$; $p = 0.004$), as well as after practice in reclined ($X2(1) = 11.919$; $p = 0.001$). More-skilled reachers performed more reaches with hands apart from the body after practice in supine ($X2(1) = 9.143$; $p = 0.002$). Less-skilled reachers performed more reaches with no grasping in seated ($X2(1) = 8.526$; $p = 0.004$) at reaching acquisition. More-skilled reachers showed more reaches with no grasping in supine at the acquisition ($X2(1) = 14.286$; $p < 0.01$), while after practice the same group showed higher frequency of reaches with grasping in seated ($X2(1) = 5.143$; $p = 0.023$). Both intrinsic and extrinsic constraints are suggested to affect the reaching movements of young infants in many different ways, that is, according to the parameters that have been analyzed, such as proximal and distal adjustments.

Parkinson's Disease Shows Perceptuomotor Asymmetry During Straight-Ahead Pointing Unrelated to Motor Symptoms

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Evidence in Parkinson's disease (PD) of neglect symptoms have been reported during visuoperceptual tasks and linked to the side of disease onset. The goal of this study was to determine if this perceptual asymmetry is also evident is perceptuomotor tasks without visual input. The task was to point to a remembered

straight-ahead (SA) target in peripersonal space. A pointing bias was evident during baseline pointing that was to the left of SA in PD patients and to the right in healthy age-matched controls. To evaluate whether this bias was linked to a proprioceptive bias in PD, pointing during axial twisting of the trunk was tested. The axial rotation (+/- 15°, 1°/sec) of the seat/lower-body about shoulders fixed against rotation induced a non-veridical perception of upper-body rotation and lower-body stationarity. Pointing behavior showed endpoints shifted to the right of the actual SA during clockwise (CW) lower-body rotation and left of SA during counter-clockwise (CC) rotation, despite the fact that the shoulders and head were not rotated. In PD patients, pointing movements relative to SA were shifted less with CW than with CC rotation of the lower-body, whereas controls showed symmetrical pointing. Both hands were tested in each subject, and bias appeared regardless of hand used. This bias in PD patients was not significantly changed by levodopa. Neither the side of PD-onset nor disease progression was linked to direction or size of pointing bias. These findings suggest that PD manifests a contraction of left external hemispace relative to right hemispace and this affects the generation and execution of motor commands throughout disease progression.

Aging-Related Changes of Finger Force Indices During Isometric Finger Extension Tasks

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Previous studies on aging have shown impairments in hand strength and dexterity in elderly people which arise from finger force flexion tests. However, aging related changes in finger extension is not well known. This study aimed to investigate age-related changes of finger interactions indices during isometric finger extension tasks. Sixteen young adults and sixteen elderly adults, gender matched subjects, produced maximum voluntary force (MVF) using either a single finger or all four-finger fingers in flexion and extension. The data were used to calculate three different variables: (1) the maximum force produced in the MVF task, (2) force sharing (the percent contributions of individual fingers relative to the sum of individual finger forces during four-finger MVF task), and (3) enslaving (the non-task finger forces during a task finger MVF task). Enslaving is inversely proportional to finger independency. Our results show that force enslaving during finger extension was greater than flexion. Also, the flexion-extension difference in enslaving was greater in elderly than young adults. The greater changes during the flexion condition could be explained by flexion dominated everyday manipulation tasks. The force sharing pattern was constant between different age groups, and non-task fingers proximal to a task finger produced a greater enslaving force than non-task fingers distal to the task finger. The decrease in force enslaving from young adults to elderly adults found in previous studies, as well as our current study, may appear counterintuitive because the impaired finger dexterity, in the elderly, reported in previous studies would suggest an aging-related increase in finger inter-dependency. Furthermore, developmental changes of the neuromuscular system due to everyday finger practice also appear to be an important aspect to account for the force enslaving differences between flexion and extension.

Hand Finger Coordination and Control in Piano Players

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For successful performance of finger manipulation tasks such as grasping, pinching and writing, the central nervous system (CNS) must control the fingers with precise and independent movements. However, previous studies have shown that humans are unable to produce completely independent finger movements due to central and peripheral factors. Pianists are known for their ability and extensive practice of individual finger pressing of keys. Studying expert piano players can provide insights about the effect of practice and experience on hand finger coordination and control. Our study investigated finger interaction indices of adult pianist and non-pianists during flexion and extension conditions. Fourteen adults (seven pianists and seven non-pianists) participated as subjects for this study. All participants were right handed based on the preference during everyday activities such as writing and eating. Subjects who have ten or more years of piano playing experience were considered pianists. Each subject was asked to produce maximum isometric pressing force (MVF) in five conditions (I-index, M-middle, R-ring, L-little, and IMRL) and two directions (flexion and extension). Force enslaving (EN-unintended unintended finger forces produced by non-instructed fingers during force production of an instructed finger; inversely proportional to finger independency) and force sharing (percentage contributions of individual finger forces to the total force at four-finger MVF) was calculated for each subject. The results show that pianists have lower EN in finger flexion than non-pianists while EN was not changed for both groups. Index finger EN was the smallest for both groups and little finger EN was the largest. The lower EN can be due to the task specific demand of individual finger movements in piano playing. The force sharing pattern is unchanged for both groups. The unchanged force sharing patterns is in concert with our previous developmental findings, thus further supporting the idea that the force sharing pattern could be an inherent property of human hand-finger coordination and control. We conclude that piano playing can improve individual finger movement control without changing the pattern of force production in multi-finger tasks.

Movement Substructure in the Left and Right Arm of Young and Elderly Adults During Goal-Directed Arm Movements

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The right-hemisphere aging model proposes that the non-dominant (right-hemisphere) ages at a faster rate than the dominant (left-hemisphere) in right-handed individuals. The purpose was to examine possible age-related differences in the movement substructure for the right and left arms during goal-directed aiming movements. Sixteen young (24 ± 4.3 yrs) and sixteen elderly adults (74 ± 4.9 yrs) performed 24 trials with the right (dominant) and left (non-dominant) arms on a digitizer tablet. Subjects were instructed to make goal-directed aiming movements as fast and as accurately as possible to visual targets. A choice reaction time paradigm was used and subjects were required to move to one of two targets presented

based on the color of the target. The targets were located 13.4 cm and at an angle of 5° to either the left or right of the subject's midline. Online visual feedback of the movement trajectory was provided during each trial. The primary dependent measures of interest were reaction time (RT), movement time (MT), dysfluency (DV), Normalized Jerk (NJ), distance covered in the primary submovement (PSM VL), and time spent in the primary submovement (PSM MT). The RT, MT, DV, and NJ were all greater in the old compared with the young adults. In addition, the PSM VL was less for the old compared with the young adults, whereas the PSM MT was greater for the old compared with the young adults. However, none of the dependent measures showed differences between the left and right arm of both elderly and young adults. These results suggest that the control and the substructure of the movements are similar between the left and right arm in right-handed elderly adults, but that the motor system guiding both limbs is altered in the elderly. These findings are inconsistent with right-hemisphere aging models that predict asymmetric decline of motor performance in the left arm of elderly adults. (Supported by NINDS 40266 and NIA 14676.)

Choice of Contact Points for Multi-Digit Grasping

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Research on multi-digit force coordination has provided significant insight into how humans partition forces and torques among digits. However, these studies prohibit subjects from choosing fingertip contact points (FCPs) on the object due to constraints imposed by force sensors at fixed locations on the object. Little is known, however, about how humans choose FCPs on an object in preparation for manipulation. To address this question, we manipulated the center of mass (CM) of an object while offering either visual, verbal, or no cues as to the location of the CM. We asked 12 subjects to reach, grasp, lift and replace an inverted ''T'' shaped object with all five digits while minimizing its roll. The CM of the object was altered by placing a 400 g weight at one of three locations (left, center or right) in the base of the object in either a blocked (B) or random (R) fashion. In B, the CM was the same for 5 consecutive trials for each location. In R, the CM was changed on a trial-to-trial basis. FCPs on the object were recorded using a motion-capture system. We measured object roll during lift to quantity grasp performance. When no cue was available, subjects were able to minimize object roll in B, but not when the CM was on the right or left during R ($p < 0.05$). Additionally, subjects altered their FCPs as a function of CM location only in B. In R, subjects placed their fingers in a ''default'' position, acting as if CM was in the center, regardless of the actual CM location ($p < 0.05$). When either verbal or visual cues were available, subjects showed a similar performance in terms of object roll between both B and R when the CM was located in either the center or left. However, when CM was placed on the right during R, subjects were not able to minimize roll as well ($p < 0.05$). Importantly, subjects modulated their FCPs as a function of CM location similarly in both the B and R conditions. These results suggest that grasp planning includes both kinematic (FCPs) and kinetic anticipatory mechanisms to optimize grasp manipulation (i.e. to minimize of object roll). Our preliminary results on the effect of cues suggest that subjects were able to retrieve FCPs appropriate to

object manipulation when CM was changed from trial to trial, but were not able to implement force coordination to the same level of proficiency.

Submovements During Pointing Movements in Parkinson's Disease

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Segmentation of movements into submovements represented by irregularities in the velocity profile is a typical feature of motor performance in Parkinson's disease (PD). An interpretation of these submovements as adjustments performed to accurately achieve the target has been widely accepted since this interpretation seems to be consistent with various features of movements in PD, such as slowness, hypometria, variability, reliance on vision, and others. The present study reexamines this interpretation based on our recent findings that in addition to accuracy requirements, motion termination also causes submovements. Two groups of subjects, PD patients and age-matched controls, performed pointing movements to small and large targets. The target size manipulation was used to emphasize the role of accuracy requirements in submovement production. Also, pointing movements were performed in three modes, discrete, reciprocal and passing. The discrete mode required target achievement accompanied with simultaneous motion termination. Reciprocal movements included target achievement and no motion termination. Passing movements required achieving (passing through) the target and terminating motion after that. Only submovements produced after crossing the target were studied during the passing mode. Comparison between the discrete and reciprocal mode allowed us to investigate whether there were submovements that emerged due to motion termination and not due to accuracy requirements. Comparison of these two modes with the passing mode provided information whether accuracy-related submovements were not corrective adjustments. Three submovement types were distinguished determined by zero-crossing in the velocity (type 1), acceleration (type 2) or jerk (type 3) profile. It was found that both groups produced submovements (namely, type 1) associated with motion termination and not with accuracy requirements. Although type 2 and 3 submovements were more frequent for small than for large targets, presence of these submovements in passing movements suggested that these were not corrective adjustments but they rather represented kinematic noise that increased during movements to smaller targets. This possibility was further supported by analyses of normalized jerk and trajectory variability. The findings suggested that in both groups, submovements of all three types were not corrective adjustments but emerged either from motion termination or as noise accompanying production of accurate movements to small targets. Differences between the two groups documented in the study pointed to an influence of PD on the ability to smoothly terminate motion and to elevated kinematic noise accompanying regulation of pointing accuracy in patients.

Non-Preferred Arm Advantages in the Coordination of Static and Dynamic Proprioceptive Feedback

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Upper limb asymmetries in motor behavior are thought to be one of the most obvious examples of lateralized brain function. This phenomenon, more generally known as "handedness," has traditionally been approached from the standpoint of motor output, where preferred right arm performance advantages in right handed individuals are thought to reflect motor dominance of the contralateral left hemisphere. Studies from this laboratory, however, have suggested a potentially complementary role for the non-preferred arm/hemisphere in the utilization of sensory feedback. In particular, the ability of subjects to perceive and replicate arm positions on the basis of static proprioceptive feedback appears to be enhanced for the non-preferred arm, especially in conditions with increased processing demands. The purpose of the present study was to examine limb asymmetries in conditions where both static and dynamic feedback must be combined to perform accurate matching. Thirteen healthy, right-handed adult subjects performed a proprioceptive matching task while blindfolded using an instrumented manipulandum designed for measuring horizontal elbow displacement. Using a torque motor system the preferred or non-preferred elbow was extended to a target position of 10, 20 or 30 degrees. Subjects were then given 3 s to memorize the target arm position before returning the arm to the start position. Following a short delay, the same (ipsilateral remembered condition) or opposite (contralateral remembered condition) forearm was slowly rotated through a range of extension angles that included the previously memorized static target position. When the subject perceived the arm to be at the target location, subjects rapidly extended the fingers of the opposite hand. The non-preferred left arm was significantly more accurate in terms of absolute ($p < .01$), constant ($p < .05$) and variable ($p < .001$) error, compared to the preferred right arm. This asymmetry was most pronounced for 30 degree targets and in the more difficult contralateral remembered condition ($p < .01$). In addition, a significant undershooting was observed for all target positions ($p < .001$). This effect was explored in a subsequent experiment, which demonstrated that this bias was related to the speed at which the arm was moved during target presentation. Overall, the present study provides further support for the notion that the non-preferred arm is dominant for proprioceptive feedback processing. This finding may reflect the role of the non-preferred arm in non-visual stabilization of objects during the performance of many two-handed activities of daily living.

Does the "Rod-and-Frame Illusion" Affect Motor Planning of Sequential Actions?

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Objective: At present, the effects of visual illusions on the planning and control of prehensile actions is largely debated. Glover (2004) proposed the planning-control model, which posits that different visuo-motor representations are used for the planning and control of actions. Planning is assumed to be influenced by context dependent representations, such as visual illusions, whereas control is not. Although ample evidence exists for the effects of visual illusions on motor planning, the evidence resides in studies using simple grasping tasks. No study has investigated the effect of visual context on motor planning in a sequential object manipulation task. This is surprising, as motor planning in sequential tasks is especially important because the object has to be picked up for a specific purpose, necessitating a particular grip to be used. Therefore, in the present study the effect of a visual illusion on the planning of a sequential object manipulation task was investigated. *Method*: Visual context was altered via the "rod-and-frame illusion," in which a bar is surrounded by a tilted frame. Participants (n = 13) had to grasp a bar embedded in the "rod-and-frame illusion," and place it in a tight fitting box in a pre-determined way. The type of grip (i.e., overhand, underhand) used to grasp the bar was registered as a macroscopic variable of motor planning. *Results*: Most participants (n = 10) switched between pronated and supinated start postures, indicating that they planned the task in such a way that allowed them to end it with a "comfortable end posture" (Rosenbaum & Jorgensen, 1992). Importantly, the exact bar orientation where switch in grip occurred was affected by the surrounding frame. Hence, the illusion had an effect on the planning of the action. Unexpectedly, some participants (n = 3) used a different strategy. They employed an initial grip that not always enabled them to end the task with a comfortable posture. Still, in these participants also, the illusion affected the bar orientation at which the switch in grip type occurred. *Conclusion*: Our findings are the first to show that motor planning in a sequential task is affected by the visual context, thereby corroborating this aspect of the model of Glover (2004).

The Effect of a Visual Illusion on Grip Planning in Congenital Hemiparesis: Hemispheric Differences

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Objective: The planning-control model (Glover, 2004) posits separate visual representations for planning and for control. As planning processes are assumed to be dependent on context information, the model predicts that planning processes are sensitive to visual illusions. Recent evidence suggests that activity limitation associated with hemiparetic cerebral palsy may be attributed to a specific planning

deficit (Steenbergen & Gordon, 2006). The results of these studies indicate that planning is especially compromised in right hemiparesis (viz. left hemispheric damage). In the present study, we directly test the assumption that there exists a hemispheric difference in the degree to which motor planning is context dependent. To that aim, grip planning in a sequential object manipulation task embedded in a "rod-and-frame illusion," was examined. *Method*: Participants with congenital left or right hemiparesis and a control group (all groups $n = 13$) had to grasp a bar that was surrounded by a tilted frame and subsequently place it in a box. Bar and frame could be independently rotated creating the illusion. Type of grip used to grasp the bar and the reaction time were registered. *Results and Conclusion:* Preliminary analysis of the results showed differences in motor planning among the three groups. Control participants switched between different start postures, so that they could end the movement with a comfortable end posture. The exact location of the switch was affected by the illusion. The majority of the participants with left hemiparesis always used the same start posture, suggesting planning of the start posture, but not of end posture. In addition, the illusion had no impact on planning. The results of participants with right hemiparesis were variable, both between and within participants. This suggests that damage to the left hemisphere not only compromises motor planning in the way that it is less anticipatory in terms of end goal, but also that it leads to motor planning being more dependent on the visual context. These preliminary findings may indicate hemispheric differences in the way that visual information is used for motor planning.

Planning and Control of Bimanual Actions I: Basic Findings on the Effects of Cognitive and Coordination Constraints

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There is ample evidence to suggest that coordination constraints, e.g., the preference to move both hands in a mirror-symmetrical fashion relative to the saggital plane, play a prominent role in the coordination of bimanual actions (e.g., Swinnen et al., 1997). Symmetrical movements, as opposed to asymmetrical ones, have a higher degree of stability and accuracy, because they often coincide with the co-contraction of homologous muscle groups (Swinnen et al., 1997). A critical cognitive parameter controlling how we plan to grasp objects unimanually is end-state comfort, i.e., the anticipated degree of physical comfort associated with the posture that is expected to be adopted at movement completion. Evidence from unimanual prehension tasks showed that participants ended up in a comfortable posture, even when this necessitates an awkward joint-angle configuration at the start of their movement (e.g., Rosenbaum et al. 1992; Kelso et al., 2004). Recently, Weigelt et al. (2006) demonstrated that the end-state comfort effect also holds for bimanual object manipulation tasks. They showed that comfortable end postures for both hands were preferred over comfortable handgrips at the start of bimanual movements. However, it was not examined how this preference affects the coordination of bimanual actions. For instance, was the comfortable ending of both hands selected at the cost of efficiency of coordination? In the present study, we investigated in more detail the relationship between cognitive and coordination constraints on motor

planning and execution in a bimanual object manipulation task. To this end, the bar-handling paradigm of Rosenbaum et al. (1992) was used as key methodology. Participants had to pick up a CD (instead of a bar) and subsequently place it in a CD rack unimanually, or place two CDs in two racks bimanually. In both conditions, placement orientation of the CDs was either vertical or horizontal, resulting in comfortable and less comfortable end postures, respectively. In addition, start posture was manipulated, yielding conditions in which planning and coordination constraints were systematically varied. Task performance was registered by three-dimensional movement recording (Optotrak) with markers on the trunk, shoulders, elbows and wrists. Kinematic parameters reflecting the efficiency of the individual hand movements and relative-phase measurements were analyzed. The results will be discussed in light of the relationship between cognitive and coordination constraints for bimanual object-manipulation.

Planning and Control of Bimanual Actions II: Conflicts Between Cognitive and Coordination Constraints

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Bimanual movement performance has been investigated from various perspectives, each with its corresponding emphasis on different constraints. From the viewpoint of coordination dynamics, an important constraint on both cyclical and discrete bimanual task performance is the preference to move both hands in a mirror-symmetrical fashion relative to the saggital plane. The co-contraction of homologous muscle groups are assumed to play a key role in the large stability and accuracy found in symmetrical movements as opposed to asymmetrical ones (Swinnen et al., 1997). From a more cognitive point of view, it is assumed that the planning of the end posture precedes the selection of a movement, as described in the "posture based motion theory" by Rosenbaum et al. (2001). Evidence from this theory stems from unimanual prehension tasks in which subjects preferred a comfortable joint angle-configuration at the end of a movement, even when this necessitated an awkward start posture (Rosenbaum et al., 1992). Finally, Mechsner et al. (2001) have demonstrated that interlimb coordination constraints can be overcome using perceptual task constraints. Thus far, the role of these constraints in the performance of bimanual tasks has primarily been studied in relative isolation. In the present study, we introduced a bimanual task including conditions where these constraints are in conflict with each other. For example, in some conditions moving both hands in a mirror-symmetrical pattern does not lead to a comfortable end posture. The task we used was an extension of the bar-handling paradigm of Rosenbaum et al. (1992). Participants had to pick up two CDs (instead of bars) with two hands and place them in a CD rack. Start and end orientations of the CDs were systematically manipulated such that conditions were created in which a conflict in constraints was present. At the start and end of the task, participants could adopt comfortable or uncomfortable handgrips as determined by awkwardness ratings. In addition, placement orientation of the CDs was either identical for both hands (e.g., placement of both CDs vertically) or not (placement of one CD vertical and the other horizontal). Behavior of participants was videotaped, and data-analysis

was performed off line. Variables of interest were end posture of the hands, and rotation direction of both forearms. We will discuss the preferences of participants for either cognitive or interlimb-coordination constraints in light of recent theories on bimanual movement control.

Modulation of the Strength of Periodic Common Neural Input to Hand Muscles During Precision Grip Is Muscle-Pair Specific

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Anatomical and physiological evidence suggests that periodic common input to motor neurons of hand muscles is an important neural mechanism for hand control. However, the principles underlying the organization of periodic common neural input to hand muscles remain controversial. Specifically, it is unclear whether the strength of periodic common input to motor units across hand muscles is task-dependent or distributed in a muscle-pair specific fashion. We addressed this question by using the frequency domain measure, coherence, to quantify the correlation of discharges of a large number of motor units residing in different hand muscles during object hold using a precision grip. To maintain the object aligned with the vertical, subjects were required to modulate the force contribution of two intrinsic index finger muscles with opposite mechanical actions in response to changes in the object center of mass. This task allowed us to test the hypothesis of whether the strength of periodic common neural input to hand muscle motor units is modulated with changes in the degree of muscles' functional coupling. Similar to our previous work, we find that the strength of periodic common input is non-uniformly distributed across pairs of hand muscles. Furthermore, the strength of periodic common input is invariant across center of mass conditions for the pair of intrinsic index finger muscles with opposite mechanical actions. However, modulation in the strength of periodic common input was evident in an extrinsic-intrinsic hand muscle pair. The present findings, together with previous observations of other hand muscles, suggest that the distribution of periodic common input appears to be task-dependent, but only in a subset of muscle pairs.

Age Related Changes in the Feed-Forward Control of Multi-Element Systems

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Recently a series of studies on multi-finger force production tasks have described the phenomenon of anticipatory synergy adjustments (ASAs). Synergy has been defined as a pattern of co-variation among finger forces or finger modes (hypothetical control signals to individual fingers that are manipulated by the controller) across repetitive trials that stabilize a performance variable such as the total force. During slow multi-digit force production tasks, negative co-variation of finger forces stabilizes the total force (a force stabilizing synergy). A change in the co-variation pattern can be observed prior to a self-generated quick change in the total force as well as in preparation to a perturbation applied to one of the fingers and triggered by the subject. In young persons, such anticipatory synergy adjustments

are seen 100-200 ms prior to the earliest change in the total force. The functional role of ASAs has been proposed to represent a purposeful decrease in the strength of force stabilizing synergies because otherwise these synergies would counteract the planned change in total force. As such, ASAs reflect an important feed-forward mechanism of control of multi-element systems. ASAs share many features with another well-known anticipatory behavior of the motor control system, anticipatory postural adjustments (APAs). In particular, both can be seen about 100-150 ms prior to an action and both shift towards the action initiation under the simple reaction time instruction. Hence, it is possible that both phenomena reflect a single feed-forward control mechanism. APAs have been shown to occur later and be of smaller amplitude in elderly individuals. We investigated the behavior of ASAs in elderly individuals in two multi-finger force production tasks. The first task required the subject to produce a quick pulse of the total force produced by the four finger of the dominant hand to a target, either in a self-paced manner or in response to an auditory signal. In the second task, the subjects produced a constant level of force with the four fingers and a perturbation was applied to the middle finger (a sudden unloading of the finger) either in a predictable manner by the subjects themselves or unexpectedly by the experimenter. In both experiments the elderly subjects displayed ASAs when the change in total force was predictable, i.e. in self paced trials in the first experiment and in self perturbed trials in the second one. Compared to similar data of young subjects, the ASAs occurred later and were of smaller magnitude. We discuss possible implications of delayed and decreased ASAs on manual dexterity in the elderly.

Experience and Body Orientation Affect the Early Control of Reaching

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Although research suggests that experience may be a better indicator of the acquisition of certain abilities by infants than age, little work addresses reaching movements in particular. This longitudinal study verifies the effect of experience on infant reaching in different body orientations. After approval from Research Ethics Committee of the University Federal of Sao Carlos, less- ($n = 6$) and more-skilled ($n = 4$) reachers aged 4-to-6-months-old were evaluated at the acquisition of reaching (no-experience) and after one month of experience obtained by spontaneous practice (experience-1). Kinematical analyses examined 3D wrist motion during reaching trials in supine (0°), reclined (45°) and seated (70°) orientations. The results indicate that there were no differences for age between less- and more-skilled reachers in no-experience ($U = 3$; $p = 0.054$) and experience-1 ($U = 8$; $p = 0.386$). Less-skilled reachers showed lower frequency of reaching in no-experience (17.7) than in experience-1 (33.0) ($X2(1) = 27.842$; $p < 0.01$), and the frequency was lower for less-skilled than more-skilled reachers (43.8) in no-experience ($X2(1) = 16.943$; $p < 0.01$). Considering different body orientations, the frequency of reaching in no-experience was lower for less-skilled reachers than for more-skilled ones in supine (2.5 versus 16.25) ($X2(1) = 31.250$; $p < 0.01$), and reclined (6.33 versus 14.25)

(X2(1) = 3.8; $p = 0.051$). In relation to kinematical analyses of reaches performed in different body orientations, less-skilled reachers in no-experience showed lower mean velocity (H(2) = 9.627, $p = 0.008$) and peak of velocity (H(2) = 10.183; $p = 0.006$) in supine, while duration (H(2) = 10.146; $p = 0.007$) was higher in this orientation. In experience-1, less-skilled reachers showed lower duration (H(2) = 6.735; $p = 0.034$) and number of movement units (H(2) = 12.912; $p = 0.002$) in seated, while mean velocity (H(2) = 16.485; $p < 0.01$) and peak of velocity (H(2) = 10.472; $p = 0.005$) were higher in this orientation. For more-skilled reachers in no-experience, there were no significant differences among the orientations. Comparisons among the more-skilled reachers in no-experience and the less-skilled ones in experience-1 showed that, in supine, the number of movement units (U = 884; $p = 0.016$) was lower for more-skilled reachers. In reclined, mean velocity (U = 777; $p < 0.01$) and peak of velocity (U = 871; $p = 0.002$) were lower for less-skilled reachers. In seated, lower number of movement units was found for less-skilled reachers (U = 715.5; $p = 0.008$). Our findings suggest that experience was a more relevant constraint than age. Furthermore, experience and different body orientations were shown to affect the course of reaching development according to the infant's skill levels. Therefore, experience and body orientations seem to be important constraints that should be taken into account when examining infant reaching development.

Does Movement Planning Influence the Use of Motor Abundance In Reaching?

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Reaching movements present invariant hand characteristics (e.g., quasi straight-line hand path) suggesting that the central nervous system (CNS) uses parameters of end-effector final position for motor planning. At the same time, recent studies show that typical reaching behaviors involve the selective use of redundant combinations of joint motions (motor abundance). The advantage that motor abundance provides may be in terms of performance flexibility, as when reaching to moving targets (e.g., catching an annoying fly). This study examined the hypothesis that the degree to which motor redundancy is used to coordinate multijoint reaching movements is influenced by motor planning and enhanced when the task requires greater movement flexibility. The uncontrolled manifold (UCM) approach was used to investigate this question. Eleven adults performed reaching movements to a target placed at arm's length under conditions where the target location was either certain or uncertain, using a double-step paradigm. For the uncertain condition the target could jump to a new location, 13 cm to the left or right, immediately after the participant started to move. Scapula, shoulder, elbow and wrist joint motions were analyzed. A geometric model that relates values of the joint configuration to a particular performance variable (movement extent and movement direction of the hand) was used to define the UCM. The across-trials joint variance was partitioned into a component corresponding to the use of different joint angle combinations to achieve an equivalent hand position (GEV) and a component leading to a variable hand position (NGEV). The pointer-tip's movement variability along the path and variable targeting error did not differ between conditions. Larger overall joint variance was found for the uncertain target condition. However, most of the

increased joint variance was GEV, which was significantly higher in the uncertain condition for control of both movement extent and movement direction. In contrast, NGEV differed between the two conditions only for the control of movement extent early in the reach, suggesting that target uncertainty led to inter-trial timing variability along the movement path. Flexible joint coordination (GEV>>NGEV) was especially important, therefore, for the control of targeting direction, which had a high probability of change in the uncertain condition. While the results are also consistent with previous studies suggesting that amplitude and direction are controlled independently, they indicate, more importantly, that greater flexibility in how the joints are combined is planned for specifically when a task is performed under uncertain task conditions.

Consideration of Human Isochrony from a Computational Motor Theory

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Previous studies on human motor control reported a phenomenon called isochrony, which is the compensatory increase of movement speed with increasing movement distance. For example, this phenomenon is observed in such handwriting movement situations as when "e" and "l" are continuously drawn. Isochrony is a general principle of movement control, not only for such arm movements as handwriting and drawing but also for head rotation and speech production. Human isochrony has been extensively researched in relation to the two-thirds power law and stroke-based segmentation hypotheses. As part of such research, even though Viviani and Flash (J. Exp. Psychol. Hum. Percept. Perform., 1995) attempted to explain isochrony by a minimum jerk hypothesis, which is a possible computational model for human point-to-point movement, isochrony has still never been explained computationally. On the other hand, in complex via-points trajectory formation, Wada and Kawato (Neural Networks, 2004) proposed a possible computational trajectory generation model that can estimate the time to pass through via-points. This model differs from traditional via-points movement generation models by suggesting that via-point time is not required as a constrained condition. This model is optimized on the condition that the Duration average of the Commanded Torque Change (DCTC) between each via-point is equal, suggesting that CNS plans via-point time according to the computational theory. We suppose that the above human isochrony can be explained by the computational theory. In this paper, we designed two tracing tasks, figure eight and double elliptical patterns, which were researched in previous isochrony studies. Measured movements were performed on seven subjects to investigate the possibility. In each task, the velocity in large segments tends to be qualitatively higher than in small segments. This means that movement speeds are increased to compensate for increasing movement perimeter; an isochronous tendency can be observed qualitatively. In duration ratio and DCTC ratio results in each task, the variation of DCTC ratio with increasing perimeter ratio tends to be less than the variation of duration ratio. Also in results for isochrony coefficient, DCTC tends to be higher than duration. That is, results show a tendency where isochrony is the phenomenon that DCTC equals rather than duration, and the possibility is suggested that isochrony is observed as a secondary effect caused by movement time planning to equalize DCTC.

Variances of Hand Positions and Arm Configurations During Arm Movements Under External Load and Without External Load

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The variances of hand positions, and angular arm configurations are studied to investigate how the variances and arm muscle activities are effected if a motor task is performed under external load. Subjects lay on a plate of weight bench and held a bar in their hands above their chest while the elbows were fully flexed. They were asked to lift the bar by fully extending their arms and then replacing the bar to the original position. The subjects executed this extension-flexion movement 10 times without load and 10 times with a bar that was loaded by 160 N. Nine young healthy subjects participated in the measurements. The coordinates of six points of the arm were recorded using a ZEBRIS movement analyzing system: one above the shoulder, two in the elbow, two in the wrist and one on the hand. From these coordinates the angular arm configuration was computed. Simultaneously, muscle activities (EMG) of the biceps brachii and triceps brachii muscles were recorded. The variance of the hand positions and the variance of the angular configurations were computed for two conditions: with load and without load. Time normalized variances were computed separately for the lifting and for the replacing phase. The averaged EMG amplitudes have been computed in the lifting phase and in the reposing phase separately with load and without load and we computed the ratio of the values obtained from these two conditions for both phases. *Results*: During the lifting phase the variance of the hand position was higher for movements without load than with load. This was true for the variances of the angular configurations as well. During the reposing phase neither the variance of the hand position nor the angular variance differed significantly for the two conditions. The ratio of the EMG values of the triceps was larger for the reposing phase than for lifting. There was no significant difference in the ratios for the biceps. *Conclusion*: We conclude that during the lifting phase the load (inducing higher muscle activities) helps to stabilize hand position and angular configuration. In the reposing phase the load has a larger effect on the triceps activity that helps to slow down and insure the smooth reposing movement but it does not enhance the stability. The method for studying the effect of load on kinematic variances is planned to discern how the level of muscle activities relate to movement stability.

Cortical Activity for Grasping an Object and Estimating the Object's Size

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For achieving motor task goals, conscious perception or awareness of one's own movement and/or task situations seems to play a role to organize a movement. On the other hand, there have been evidences such that a movement can be produced and/or adjusted without conscious control of the movement (e.g., Goodale & Milner, 1992; Goodale, Pelisson, & Prablanc, 1986). Based on these findings, for instance,

organizing finger configurations for grasping an object may not be necessarily accompanied by cognitive processing to assess the object's size. In turn, using the index finger-thumb aperture to estimate the object's size may require visual information processing. How does cognitive information processing or conscious perception associate with the production/modulation of a movement? To address this question, the present study attempted to identify qualitative features in the cortical activities during organizing the index finger-thumb aperture for two motor tasks, grasping an object and estimating the object's size by the aperture configuration. Ten participants performed two motor tasks as follows. They sat on a chair in front of a computer display, on which a target object (a circle with 3 cm diameter) was displayed. Two seconds after the object onset, an auditory cue was given for initiating the task performance. In one task condition, they reached to the target object and touched it so as to grasp it with a pinch grip (RG condition). In another condition, they pantomimed with the pinch grip to match the aperture with respect to the object's size (Matching condition). They performed 80 trials for each task condition. GonioMeter was used to register the angular configuration of the index finger-thumb aperture, sampled at 400 Hz. EEG data was sampled at 1,000 Hz by 64 channels (Neuroscan, USA). The change in event related power spectrums during the task performance was analyzed to focus on the event-related desynchronization (ERD), which is regarded as the cortical activation with increased excitability. After the object onset, ERD increased in a broad frequency range over the frontal area of the cortex particularly in Matching. During the pinch motion, the occipital and parietal area showed high ERD over a wide frequency range in RG, but not in Matching. ERD over different frequency ranges in the two task conditions was observed in the frontal area and the sensorimotor cortex. These results suggest that ERD can reflect the qualitative difference in cortical activity depending on the cognitive processing associated with a task performance.

Moment of Force Stabilization Within a Task That Requires Stabilization of the Total Force During Multi-Finger Isometric Tasks

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Several studies used the framework of the uncontrolled manifold (UCM) hypothesis to quantify the multi-finger synergies stabilizing the total force and moment of force in multi-finger tasks. In this analysis, variance within the UCM is compared to variance orthogonal to the UCM. Little has been known, however, about variance distribution within the UCM. Subjects produced accurate steady-state values of the total force at 5%, 7.5% and 10% of the four-finger maximal force. The force sensors could rest on the table (stable) or on a narrow support (unstable) placed between Index and Middle fingers (Pivot_IM), Middle and Ring fingers (Pivot_MR), or Ring and Little fingers (Pivot_RL). Indices of co-variation of finger modes (hypothetical commands to fingers) across trials showed synergies stabilizing the total force in all the conditions and the total moment only in the unstable conditions. Principal component analysis (PCA) of the projections of the force modes onto the UCM for

the total force stabilization showed the following major results. In the Pivot_MR condition, the PCs showed that fingers formed two pairs showing negative mode co-variation, I-M and R-L. In other two Unstable conditions these two PCs were seen less frequently, and they were all but absent in the Stable condition. These results show that the redundancy of the four fingers allows one to achieve force stabilization together with stabilization of the moment of force. Adding such a secondary constraint does not seem to interfere with the force stabilizing synergy. The flexible solutions used by the subjects in Unstable conditions emphasize the main advantage of using multi-finger synergies and comply with the principle of superposition.

Motor Overflow in Multi-finger Force Space

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The aim of this study was to investigate the contralateral motor overflow in children during finger maximum force production tasks. Forty-five right handed children, 5 to 11 years of age produced maximum isometric pressing force in flexion or extension with single fingers or all the four fingers of their right hand. The forces produced by individual fingers of the right and the left hands were recorded and analyzed in four-dimensional finger force space. The results showed that increases in task/right hand finger forces were linearly associated with non-task/left hand finger forces. The ratio of the non-task hand finger force magnitude to the corresponding task hand finger force magnitude, defined as motor overflow magnitude (MOM), was greater in extension than flexion. The index finger flexion task showed the smallest MOM values. The similarity between the directions of task hand and non-task hand finger force vectors in four-dimensional finger force space, defined as motor overflow direction (MOD), was the greatest and smallest for index and little finger tasks, respectively. MOM of a four-finger task was greater than the sum of MOMs of single-finger tasks. No single-finger or four-finger tasks showed significant changes of MOM or MOD with children's age. We conclude that the contralateral motor overflow in children during finger maximum force production tasks is dependent upon the task fingers and the magnitude and direction of task finger forces. A general schematic model is proposed in the discussion to account for general phenomenon of motor overflows.

Force Coordination in Static Manipulation Tasks: Effects of the Change of Direction and Handedness

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When manipulating an object the grip force (acting perpendicularly to the object's surface; GF) has to be closely adjusted to load force (tangential to the object's surface; LF) that tend to cause slippage. Although the elaborate GF-to-LF coordination is generally a well known phenomenon, certain important aspects have not been studied yet. For example, it remains unknown whether the recently demonstrated low level of force coordination associated with consecutive changes of LF direction (i.e., "bidirectional tasks") represents a distinctive force control pattern, as well as

whether the hand dominance plays a role in GF and LF coordination in general. To explore these aspects of force coordination 14 participants were instructed to bimanually hold externally fixed handles applying a precision grip and exert the prescribed sinusoidal pattern (2 Hz) of LF in vertical direction. However, the changes in LF maxima and minima were set in a way to produce a gradual shift from unidirectional to purely bidirectional LF exertion. The results revealed higher indices of coordination, i.e., lower GF/LF ratio (0.714 vs. 1.042, averaged cross the uni- and bidirectional tasks, respectively), higher correlation between GF and LF (0.98 vs. 0.93), higher gain (0.55 vs. 0.21) and lower offset of GF with respect to LF (0.66 vs. 4.41 N) in unidirectional trials than in all bidirectional ones independently of how "bidirectional" they were. The non-dominant hand demonstrated both a higher gain of GF (0.36 vs. 0.29) and a directionally more accurate exertion of LF. Regarding the effect of change of LF direction, the results generally suggest the existence of two partly distinctive neural control mechanisms for the GF-LF coordination. Specifically, whenever LF switches from the "main force direction," even when the magnitude of that switch is minimal, the elaborate GF and LF shows marked deterioration. The neural basis of this phenomenon, such as a potential role of muscle synergies or afferent sensory feedback, requires further studies. Regarding the effect of handedness, certain aspects of task performance and force coordination revealed the advantage of the non-dominant hand. We speculated that this advantage in controlling forces could represent an addition to the current views of the non-dominant arm/hemisphere advantage in controlling limb position.

The Potential Role of Muscle Synergies and Skin Sensory Receptors in Force Coordination in Static Manipulation

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Object manipulation is one of the most important motor activities and its control has been the object of study for many years. For a proper object manipulation the grip force (GF; normal component of force acting at the finger-object contact area) should be applied by the digits against the object's surface in order to prevent the slippage. A number of studies have shown a close coordination between GF and the external forces, also referred to as load force (LF; tangential component which tends to cause slippage), in several dynamic and static manipulation tasks. However, our previous studies have shown that a high coordination of GF and LF in static manipulation tasks becomes disrupted when LF changes direction, regardless of the difference in the magnitude of LF exerted in either of the directions. We hypothesized that this phenomenon could have either a muscle control (i.e., switching synergies between GF and two antagonistic LF muscle groups) or a sensory activity origin (i.e., changes in the pattern of the afferent firing of the skin receptors associated with the changes in LF direction). Therefore, the aim of our study was to discern possible roles of muscle synergies and activity of skin receptors in this phenomenon. Fourteen participants exerted a sinusoidal LF against an externally fixed handle in trials that gradually changed from unidirectional (LF

exerted only in one direction) to fully bidirectional (consecutive LF peaks equal in both directions). Three forearm supports (i.e., no support, single support, and double support, where the single support counteracted the arm weight) were also applied. This affected the action of arm muscles exerting LF, but not the force applied against handles. As expected, the results revealed an abrupt decrease in all indices of GF-LF coordination when the task switched from uni- to bidirectional. However, the change in external support demonstrated no effect on the studied force coordination. Since the external support alters muscle synergies, but not the forces acting at the finger-handle contact area, we concluded that the switching in sensory afferent activity rather than switching of muscle synergies is likely to play a role in the studied phenomenon. Further research is needed to reveal whether our findings regarding the distinction between the force coordination in uni- and bidirectional tasks could be extended to manipulation tasks in general.

Kinematic Profile of Reaching Movements in Post-Stroke Hemiparetic Subjects

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In the clinical practice, we could notice that the arm reaching movements made by hemiparetic subjects are characterized by coordination and recruitment of additional degrees of freedom. However it is difficult to quantify these deficits in an efficient way. This study aims to measure the motor impairment with the kinematic capture system and to compare the movement profile of hemiparetic patients with normal subjects. Ten healthy subjects volunteered (Group 1 – G1) and ten post-stroke hemiparetic patients (Group 2 – G2) with a mean score of 34.9 (+/- 17.93) in the Fugl-Meyer Scale and 89 (± 8.43) in the Barthel Index were selected from the Physiotherapy and Occupational Therapy Outpatient Unit of the University Hospital – UNICAMP. Kinematic data were recorded by an infrared system of motion analysis (Qualisys Medical AB – version 2.57) with frequency of 240 Hz and filtered with a 6 Hz low pass filter FIR (MATLAB program). For the capture, the subjects were invited to fit a cone into a target placed within arm's length. In the sagital plane, the following kinematic variables were evaluated: time of maximum peak velocity (percentage ratio of total time -%), number of velocity peaks (n), and maximum velocity (m/s). For the horizontal plane, the trunk and wrist displacement (m) and the index of curvature were computed. Mann-Whitney's test was used to compare the two groups and the significance level adopted for the statistical tests was 5% ($p < 0.05$). Statistical difference was found among the groups in the rate (G1 – 48 ± 8; G2 – 34 ± 17; $p = 0.015$), velocity peaks (G1 - 1.8 ± 0.79; G2 - 16.2 ± 10.89; $p < 0.001$), index of curvature (G1 - 1.04 ± 0.02; G2 - 1.30 ± 0.27; $p = 0.003$) and trunk displacement (G1 - 0.026 ± 0.007; G2 - 0.114 ± 0.083; $p = 0.002$). No statistical significance was detected for the wrist displacement (G1 - 0.374 ± 0.025; G2 - 0.393 ± 0.036; $p = 0.150$). The quantification of the deficits presented in the reaching movement tasks was possible through the kinematic analysis system. The motion trajectories performed by the hemiparetic subjects were fragmented, slow

and presented an excessive use of trunk when compared with the healthy subjects. (This research was supported by FAPESP grants 05/51565-1.)

Arm Reaching Movements in Tetraplegic Patients

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The impairment of the upper limb in tetraplegic subjects results in a great lack of functionality. The reaching movements performed by these subjects are characterized by compensatory strategies that clinically might not be evaluated. The present study aims to evaluate the tetraplegic arm reaching movement using the kinematic analysis. Five C7 (ASIA) tetraplegic subjects (TS) in a chronic phase (more than one year post-ictus), with a mean score of 46.0 ± 15.7 in the motor sub-section of the Functional Independent Measure (FIM) and a mean age of 29.9 ± 9.95 years old were studied. Ten healthy subjects (HS) (mean age of 27.7 ± 7.17) were recruited into the control group. For the kinematic capture, an infrared analysis system was used with a frequency of 240 Hz filtered with a 6 Hz low pass filter FIR (MATLAB program). The record was made for the dominant upper limb using five reflexive markers placed on the wrist ulnar styloid process, the lateral humeral epicondyle, bilateral acromial processes and the vertical axis of the sternum. Time of maximum peak velocity (percentage ratio of total time -%), number of velocity peaks (n), maximum velocity (m/s), trunk and shoulder girdle displacement (m), index of curvature and length of wrist trajectory were computed. Mann-Whitney's test was used to compare the two groups and the significance level adopted for the statistical tests was 5% ($p < 0.05$). A significant statistical difference was found for both groups in the shoulder girdle displacement (TS - 0.058 ± 0.052; HS - 0.115 ± 0.038; $p = 0.037$), index of curvature (TS - 1.12 ± 0.024; HS - 1.08 ± 0.03; $p = 0.027$), maximum velocity (TS - 0.627 ± 0.0118; HS - 0.849 ± 0.142; $p = 0.014$) and number of velocity peaks (TS - 4.06 ± 1.75; HS - 1.76 ± 0.73; $p = 0.014$). In the variables trunk displacement (TS - 0.019 ± 0.012; HS - 0.034 ± 0.021; $p = 0.111$), length of wrist trajectory (TS - 0.419 ± 0.026; HS - 0.430 ± 0.44; $p = 0.806$) and percentage ratio (TS – 50 ± 7.1; HS – 56 ± 2.0; $p = 0.141$) no statistical significance was present. The present study concludes that the tetraplegic subjects demonstrate slower and less smooth reaching movements than the healthy subjects, but they are able to practice these tasks. (This research was supported by FAPESP grants 06/58891-4.)

Adjustments on Reaching Movements of a Down Syndrome Child

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Down syndrome (DS) children have been shown to acquire motor skills later and to produce movement patterns differently than typically-developing (TD) children. However, reaching behavior in this population, specifically adjustments performed when reaching for distinct objects, is poorly understood. The aim of this longitudinal study was to verify adjustments on reaching movements in relation to object size and rigidity in a DS child at the ages of 8 and 36 months. A DS and a TD child were seated on a chair inclined at 50° from horizontal and presented with four objects of different sizes and rigidity. Eighty reaches were analyzed by means of 3D movement reconstruction. Dvideow system was used to verify distal adjustments (horizontal, vertical and oblique hand orientation; open, closed and half-open hand), grasping, velocity peak, time after velocity peak, and movement duration when reaching for the objects. At 8 months, both children reached for the large rigid object with hands predominately open ($X2(3) = 14.826$; $p = 0.002$), while DS child showed lower grasping frequency ($U(1) = 73.00$; $p < 0{,}0001$), lower velocity peak ($U(1) = 8.00$; $p < 0.0001$), and longer movement duration ($U(1) = 9.50$; $p < 0.0001$) than TD child. At 36 months, no significant differences were found among the objects for all variables. Hand orientation was mostly horizontal in DS child, and mostly vertical in TD child ($U(1) = 124.00$; $p = 0.029$). Time after velocity peak was longer for DS child ($U(1) = 45.50$; $p < 0.0001$). The results suggest that both DS and TD children were able to adjust hand configuration at 8 months. According to size and rigidity information and its relation with their hand size, the children extended their fingers further so that they could touch a large rigid object. The fact that this adjustment was not observed at 36 months may indicate that factors such as growing and increased movement control influenced the perception of object affordances in a manner that adjustments were not necessary. DS child was shown to adopt distinct adaptative strategies for reaching: at 8 months, slower and longer movements were performed, and fewer grasping movements were achieved; at 36 months, the movements were deaccelerated for a longer period, resulting in a longer time to adjust hands to the object. This strategy, as well as horizontal hand orientation, may have contributed to increased grasping frequency. Although DS child was able to perform adjustments to objects, the strategies adopted seem to indicate that DS children show distinct organization of organic systems, that is, structurally and functionally different from TD children.

Influence of the Material Used in the Seat of a Chair on the Prehension Force

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The aim of the present study was to investigate the influence of the material used in the seat of a chair on the prehension force of individuals with cerebral palsy during the execution of a handling task in a sitting posture. Eleven adolescents with spastic cerebral palsy participated in the study. The subjects sat on an adjustable chair in front of a table and they were asked to move an object with a built-in force transducer from a given point to another. Force and electromyography activity were recorded

during the movement. The chair was adjusted according to anthropometrical characteristics of each subject and allowed the change of the seat-surface: canvas or wood. The type of seat-surface was randomly changed across trials. A non-parametric Wilcoxon test was used to compare the effect of the seat surfaces on the dependent variables. With the chair with canvas seat, the mean (± 1 SD) movement time was 3.4 ± 1.8 s, and with the wooden seat, it was 2.4 ± 1 s. The participants used the same prehension force for execution of the task: with the canvas seat, the mean (± 1 SD) force was 1.9 ± 1.5 N, while for the wooden seat it was 2.0 ± 1.8 N, (p = 0.79). We conclude that the type of seat surface does not influence the level of prehension force during a handling movement in a sitting posture.

Multisensory Integration During Sensorimotor De-adaptation

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Introduction. Previous research has demonstrated that adults can adapt to novel sensorimotor perturbations, a process thought to be achieved by the gradual update of an internal representation (e.g., Shadmehr & Mussa-Ivaldi, 1994). However, few research studies have investigated the persistence of a newly acquired representation, as assessed by the reduction of performance errors after the perturbation has been removed (i.e., de-adaptation). The objective of this research was to determine if visual and proprioceptive afference could be flexibly re-weighted in order to de-adapt to novel sensorimotor perturbations. *Method*. Seventy-two right-handed adults performed a center-out reaching task on a digitizing tablet positioned below a horizontally-oriented computer monitor that provided visual feedback of target circles and task performance. During adaptation trials, participants were exposed to either an incremental visuomotor rotation or a gain distortion. During the subsequent post-exposure phase, the visual feedback was provided in one of three ways: 1) on-line visual feedback with knowledge of end-point position, or 2) no on-line feedback but visual end-point position, or 3) neither on-line feedback nor end-point position. Performance was assessed by standardized initial directional error (IDE) and initial amplitude error (IAE) for the rotation and gain distortion tasks, respectively. *Results*. All participants demonstrated strong aftereffects in the post-exposure phase, indicative of adaptation to the visuomotor perturbations. To assess between-group differences in rate and final level of de-adaptation, distortion by feedback (2 x 3) ANOVAs were conducted. Results indicate that the participants primarily utilized visual afference to de-adapt to both distortions, despite the fact that adaptation to the visual rotation resulted in movement errors in azimuth, whereas gain adaptation resulted in movement extent errors. *Conclusions*. Consistent with Jones et al. (2001), proprioceptive input is down-weighted during exposure to a visuomotor distortion in order to resolve the experimentally-introduced visuoproprioceptive conflict. Proprioception continues to be down-weighted during the post-exposure phase despite the removal of the sensory conflict, suggesting the CNS fails to flexibly re-weight sensory information during visuomotor de-adaptation. These data will be discussed with preliminary findings investigating multisensory integration during a reaching task that manipulates proprioceptive, as opposed to visual, information. (Supported by: NIH R01HD42527and NIH RO3HD050372)

Can the Brain Predict the Consequences of Our Actions in Real-Time?

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Current theories suggest that the human brain can perform predictions by relying on neural networks that capture the causal relationship between the motor commands sent to our limbs and the dynamic behavior of our body. Such neural networks are called forward internal models (FIM). The concept of FIM appears particularly relevant for object manipulation tasks. Indeed, it has been shown repeatedly that our grip force is adjusted in a predictive manner with respect to the mechanical consequences of our actions, so that the object does not slip under the influence of the arm motion. It is often assumed that that the brain predicts the outcome of the movement in real-time by using copies of currently planned motor commands (efferent copy). However, accurate motor prediction has only been demonstrated in situations in which the original action plan was unaltered during the unfolding of the movement. Still, it is well known that humans have the ability to adjust their motor commands during movement execution to compensate for unexpected events. In particular, humans can adjust the trajectory of hand movements even when the target is displaced near movement onset. To determine whether motor prediction is truly a real-time process based upon the ongoing motor commands sent to the body, we monitored grip force adjustments when transporting an object to a target location that changed unexpectedly. We hypothesized that if motor prediction is performed in real-time, then grip force should remain adequately controlled despite the introduction of movement corrections. Practically, eight subjects were asked to grasp and transport an object attached to an elastic cord to a visual target located 8, 16, and 24 cm away from the resting position. Occasionally, when the target was presented at 16 cm, the target could jump unexpectedly to 8 or 24 cm at movement initiation. Our results confirmed earlier reports showing that subjects are able to compensate for target displacements. More interestingly we observed that grip force control did take into account the mechanical changes associated with movement corrections. Furthermore, when the target switched from 16 to 24 cm, grip force corrections were initiated 70 ms before arm movement corrections. We interpret those results as evidence that the brain has the ability to predict the behavior of our body even when motor commands are changed in response to unexpected events. This supports the idea that motor prediction is a real-time process continuously engaged during movement production.

Effect of Nicotine on Motor Control

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The incidence of tobacco smoking in Brazil is approximately 15 million despite a large number of reports on the impact of the exposure to nicotine, the neuroactive compound of tobacco, on human health. Several studies have reported physiological

effects in a variety of soft tissues induced by the continuous exposure to nicotine. Based upon these changes provoked by exposure to tobacco, it seems pertinent to ask if the continuous exposure to tobacco may also influence the motor control. Therefore, in this study the performance of smokers and nonsmokers in a unimanual task was examined. Specifically, the purpose of this investigation was to compare the movement time displayed by smokers and nonsmokers in a reciprocal tapping task. Ten young adults (20–25 years of age), five smokers and five nonsmokers, participated in the experiment. The participants were all right-handed and the smoker group was composed of adults who smoked over 17 cigarettes per day at least 3 years. Each participant was brought to the Integrated Laboratory (LABINTE), Dept of Physical Education, UNICEP at São Carlos, Brazil, and, after a brief period of adaptation to the laboratory environment, was prepared for the experimental session. In each trial, participants performed 20 alternated taps in two rectangular targets with a pen. They were instructed to carry out the task as accurately and quickly as possible. The widths of the targets and the distances between them were manipulated resulting in three conditions of difficulty. Ten trials for each condition were performed. The movement time was obtained in each trial and the average movement time in each condition was calculated. In order to evaluated the effects of group and conditions a 2 × 3 (group × condition) ANOVA was conducted, with repeated measures on the last factor. The dependent variable was movement time in seconds. Results revealed that smokers displayed movement time higher than nonsmokers and that movement time increased as task difficulty increased for both groups. Moreover, the effect of task difficulty was different for smokers and nonsmokers. The increase for smokers was higher than for nonsmokers. Based upon these results, it may be suggested that the continuous exposure to tobacco degrades the performance in manual skills task. Smokers not only are slower than nonsmokers but also they seem to be more sensitive to task constraints than nonsmokers.

Grasping a Disgusting Object: Does It Enhance the Readiness Potential?

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The readiness potential (RP) is a preparatory brain activity that precedes the execution of a given action. It was already reported that unpleasant stimuli capture attention, facilitate extension movements of the arm and evoke a freezing-like posture. The present study investigates the RP during the motor preparation to grasp unpleasant disgusting objects. Healthy right-handed participants (n = 12) performed the tasks. Twelve glasses each containing different types of disgusting objects and other 12 with different neutral contents were presented in a randomized order, one at a time, in two blocks of 48 trials with four repetitions of each glass. Electroencephalography (EEG) was recorded through 20 electrodes according to the 10/20 system (sampling rate of 600 Hz and the band-pass filter set between 0.05 and 35 Hz). The electrode impedance was kept below 5μV. Simultaneously, we acquired the myoelectric activity of the extensor carpi radialis longus. A load cell placed over the hand indicated the beginning of the movement of grasping. We

analyzed two intervals of the signal, one from 1.5 s to 0.5 s before the beginning of the movement (early RP), and another from 0.5 to zero, that is, the beginning of movement (late RP). We calculated the mean amplitude and the slope for each interval. Our results using paired t-test revealed larger early RP slopes ($p = 0.02$) for disgusting glasses (1.91 ± 3.07) in Cz channel (corresponding most likely to supplementary motor area), in comparison to that of neutral ones (-0.93 ± 2.43). In addition, the mean amplitude of late RP was marginally significant ($p = 0.05$) when comparing movement towards disgusting (-3.24 ± 5.10) and neutral (0.37 ± 3.55) contents in Cz channel. These results suggest that the preparation for a movement directed towards aversive stimuli, as compared to neutral, engage more processing resources and may activate defensive cortical motor representations.

Analysis of Reaching Movements in Preterm Infants

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Although studies demonstrate that preterm (PT) and fullterm (FT) infants exhibit some differences in their motor abilities, it is rare those who investigated differences in reaching and, particularly, how the kinematic variables of these abilities present themselves on PT infants. So, this longitudinal study verifies the development of reaching behavior in 5-7-month-old preterm infants by analyzing movement success and kinematic variables (straightness and adjustment index, movement unit, mean and final velocity). The participants were nine low-risk preterm infants. Ten fullterm infants served as control. In both groups, kinematic variables were not changed over age, except for the adjustment index in the preterm group. Frequency of successful reaching increased in both groups over age. Movement success was not significantly related with the kinematic variables in the full term group, while in the preterm group it was significantly related with the adjustment index alone. At 6 and 7 months, preterms showed lower mean and final velocity and higher adjustment index when compared with fullterms. The unchanged kinematic variables suggest a stable phase in the development of reaching behavior. Slower movements and greater adjustments may be adequate strategies of preterms to perform successful reaches.

Reaching to Moving Targets After Deafferentation

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We report performance on a reaching double-jump task from JDY, a subject with severe proprioceptive deficits due to a peripheral deafferentation. Stimuli were projected onto a half-reflecting mirror such that they appeared to be in the plane of a digitizing board below the mirror. A start circle appeared, followed by a fixation point either 20 or 30 cm away from the start circle. After fixation point presentation, a target circle appeared 30 degrees left or right of the start circle, parallel with the fixation point. Holding a digitizing pen in her right hand, JDY was instructed to quickly yet accurately move her hand from the start circle to the target circle. JDY was unable to see her hand and received visual feedback of her hand position (in the form of a cursor) for only the first 40 mm of the movement. On 60% of trials, the target was stationary (no jump). On 40% of trials, the initial target "jumped"

60 degrees to the other stimulus position (final target) at the same time that visual feedback of the hand position was removed. In all trials, the final target remained visible until trial completion. Several measures of performance were calculated. First, on both no jump as well as jump trials, the initial movement direction from start to target was similar to normal controls. Second, the endpoint of her movements were inaccurate, significantly overshooting the target on both jump and no-jump trials. Third, in order to explore JDY's knowledge of her arm position during the reach, the angle of movement correction on jump trials (the angle between the pre-jump and post-jump movement segments) was calculated. For jump trials, the angle of movement correction was significantly correlated with the distance (but not time) of movement from start to turn point, with larger angles correlated with longer start to turn distances. This suggests that information about movement distance, possibly generated from the efference copy, is used to inform subsequent motor planning. Although JDY's on-line movement correction was informed by information about arm position, this information did not appear to be available for control of final arm position. We discuss these results with regards to two-stage movement planning theories, specifically discussing the relative contribution of proprioception to initial and terminal movement stages as well as to movement direction and amplitude control.

Learning Mechanism in Reaching Movement under Target Jump Paradigm

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It has been proposed that reaching errors arising from unpredictable changes in target location, called target errors, are different from that arising from unpredictable force or visual perturbations, called execution errors. Furthermore, strong trial-by-trial adaptation has been found in response to random execution errors but not random target errors, even though all these errors lead to similar on-line corrections. On the other hand, it is clear that subjects will learn if the target always jumps in the same direction, i.e., they will move predicatively in the expected jump direction. This raises the question of what the learning mechanism is underlying target jump paradigm, if it is not in a trial-by-trial manner. Especially, is this learning mechanism more optimal than the trial-by-trial learning in the target jump paradigm so that it is preferred? To address these issues, we asked subjects to reach to a visual target in a virtual environment setup, where they see a curser indicating the hand. The target is displaced during the movement following a Markov Chain. By changing the transition probability, we are able to systematically vary the statistics of the target jump. Our first experiment aims to answer the question whether people will show trial-by-trial learning if the jump is no longer random, i.e., the jump is more likely to be as the same as in the previous trial. There are two possible jumping times, early or late. Meanwhile, the cursor of hand shows either the real hand movement or a delayed one. Interestingly, strong trial-by-trial learning is observed only in late but not early jumps. Furthermore, clear aftereffect is observed when the cursor of hand is also delayed. This result suggests that the motor system tends to rely more on the visual feedback in on-line correction and would use prediction only

when necessary. We also conduct another block where subjects are asked to reach to where they believe the target will be and the true target is shown only when the movement is finished. This provides us a baseline where no visual feedback can be used in on-line correction. To study whether the motor system learns to predict in an optimal way, we do a second experiment, where the transition matrix is set to random, correlated, or circular in three blocks respectively. Bayesian inference explains the data better than the trial-by-trial learning in the correlated block but not the circular block. This suggests that the motor system may use a more optimal strategy than trial-by-trial learning.

Performance in Interceptive Actions as a Function of Visual Pursuit

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Human capacity to intercept a moving target has been explained by the use of accurate visual information provided by continuous foveation of the moving target up to physical contact. This would be particularly true if visuomotor control were based on a direct linkage between visual afference and the motor system employed for interception. If, on the other hand, an individual uses an internal model based on the initial displacement of the moving target, peripheral vision might be equally appropriate to specify time to contact, following foveation of initial target displacement. This issue was tackled by comparing performance in an interceptive task in two experimental conditions, differing in the mode of visual pursuit of a moving target. Our investigation was conducted on six participants, 19-25 years old. The apparatus consisted of a horizontal electronic trackway, having a ball-like force transducer embedded at one extremity. A luminous stimulus (target) was displaced at different constant velocities, 2.25 or 3.0 m/s, from one end of the trackway to the other one, in the direction of the participant. These velocities were varied randomly across trials. The task consisted of hitting the transducer with a badminton racquet, using a forehand drive, simultaneously with the arrival of the moving target. Two experimental conditions were compared. In one condition, participants employed a continuous visual pursuit of the target (pursuit group), foveating the moving target throughout its displacement on the trackway. In the other condition, visual focus was maintained on the departure location of the target (static group), using peripheral vision to pursuit target displacement. On each condition, participants performed 50 trials, with the last 10 trials used for analysis. Contrast between experimental conditions was conducted on temporal errors. The results showed that no significant differences were detected between groups, either for absolute (pursuit: $M = 56.48$ ms, $SD = 21.20$; static: $M = 68.05$ ms; $SD = 22.53$), or constant (pursuit: $M = 29.95$ ms, $SD = 41.50$; static: $M = 8.42$ ms, $SD = 59.41$) errors. These results support the notion that time to contact is estimated mainly from the initial portion of target displacement, while the following visual afference seems to be of minor importance in the temporal organization of interception.

Posture and Balance

Neuromuscular Control Model of the Human Standing Posture

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This work presents a model of the human neuromusculoskeletal system for investigation of the postural control in standing. In addition to the extrafusal muscle tissue properties, commonly used in traditional muscle models applied to the study of human movement and posture, this model takes also into account the intrafusal muscle tissue properties and the intrinsic reflex responses provided by three neuromuscular organs (muscle spindles, Golgi tendon organs and Rhenshaw cells), which are two physiological components relevant in a postural control system. The proposed model treats the body as a single-link inverted pendulum operated by a pair of muscle-reflex actuators controlled by a proportional-integral-derivative (PID) controller. Simulations were made with and without the contribution of the modeled reflex responses. They showed fundamental properties of the somatosensory feedback system reported in investigations employing experimental data: (i) its anticipatory characteristic; (ii) its capacity to maintain, by itself, the human body in standing posture; and (iii) the incapacity of the body of supporting itself in the absence of the modeled reflex responses. From our results it is possible to conclude that the modeled reflex responses play a fundamental role in the upright posture. Our model may be used to formulate hypotheses about the origins of the somatosensory feedback deficits in postural control.

The Inadequate Use of the Classical Romberg Test to Identify Postural Blind Subjects

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The expected decrease of body sway by visual feedback has not been reported for about 30% of the subjects. Thus, it has been suggested that the visual system is not correctly integrated in the mechanism of the postural control, and hence, these subjects are denominated as postural blind or non-vision. This work focuses on investigating the influence of two distinct eye condition protocols in classifying the visual strategy in postural control. The stabilometric test was conducted for a casuistry of 144 healthy subjects (aged 18–40) with open (EO) and closed (EC) eyes to obtain the center of pressure (COP) displacement signals in the x-y plane. The reliability of the visual contribution to maintain the balance was investigated based on the variability of the COP elliptical sway area (A), the mean velocity (V) and the classical Romberg's Quotient score (RQ). In the EO condition, the coefficient of variation of A (0.56) and of V (0.21) was lower than that in EC (0.79 and 0.41, respectively). Moreover, the parameter V resulted in the lowest coefficient of variation in both eye conditions. Although A and V parameters were found to be positively correlated with its respective RQ, only in the EC condition the correlation ($r = 0.51$ and 0.85, respectively) was statistically significant ($p < 0.05$). The one-way ANOVA of the six subgroups in which the casuistry was divided (according to RQ-scores ranked in an increasing order) indicates that there is difference among their

mean values of A and V, except for the EO condition ($p = 0.34$ to A and 0.18 to V). This result suggests that the visual system can be considered properly integrated for the posture control. Furthermore, the increasing of the subgroups mean values with EC demonstrates the effect of the visual deprivation in the upright stance. Based on the sensory integration development theory, the present findings suggest the sensorimotor strategies as a particular integration pattern, and thus depending on the information deriving from a new oscillatory condition. This explains why subjects having no visual deficiency or equilibrium disorder sway less in the EC condition. Therefore, V leads to better accuracy than A in measuring the visual contribution to posture and hence reflecting the visual sway control with EO even for RQ < 100. In conclusion, the RQ parameter cannot be used alone for classifying subjects as postural blinds since its distribution does depend on the EC variability.

Assessment of Postural Stability Index Based on Spontaneous Body Sway

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Upright stance is inherently unstable and only due to active neural control the postural stability could be maintained. Many dysfunctions of neural and motor systems may lead to a decline of postural stability without discernible clinical symptoms. Force-plate posturography which is commonly used in clinical testing allows for assessment of postural sway—the signal which is believed may provide insight into postural stability control. Therefore many scientific efforts were undertaken to isolate sway characteristic changes which may be specific and at the same time may possess sufficient discriminative power for assessment of postural instability. This study remains in the line of search for spontaneous sway parameter(s) that might provide information on dynamic performance of the postural stability control. For this purpose the center of mass (COM) and the center of foot pressure (COP) time series have been recorded simultaneously in 12 healthy elderly subjects in two typical experimental conditions: while standing with eyes open (EO) and with eyes closed (EC). From a battery of commonly exploited sway measures only few exhibited sufficient sensitivity to visual conditions. Among them, the mean COP antero-posterior (AP) position as well as the AP COM and COP path lengths confirmed their high sensitivity to visual conditions. Based upon sway path length a new measure of postural sway—the complexity index (SCI)—has been introduced. This simple measure which contains both information on the COM spontaneous oscillations and their active control can be solely and easily calculated from the force-plate data. The SCI confirmed its potential value for a quantitative assessment of postural stability decline due to exclusion of visual feedback in the elderly.

Cinematographic Analysis of Movement from a Kneeling to a Standing Position in Healthy 20 to 28 Year-Olds

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Motor control is extremely important; it works as a guide to the physiotherapist who deals with those with neurological deficiencies. The aim of the present work was to evaluate the angular kinematics of the elbow, shoulder, trunk, hip, knee and ankle joints on the sagital plane during the posture changes from quadrupedalism

to bipedalism. Twelve volunteers, six women and six men had participated of this study, with ages from 20 to 28 years old. The individuals had been selected by means of evaluation respecting the inclusion criteria and exclusion after to sign the term of free and clarified consent. Six repetitions were realized, three initiates with the right side and the others three with the left side. *Results*: All results noticed, that did not have difference inter-individuals ($p < 0.001$) and intra-individuals ($p < 0.05$). The results had graphically shown to have two distinct groups, they had been submitted to a new statistical analysis and was not found significant statistically difference inter and intra individuals in the two tested groups. Group A: analysis inter-individuals with $p = 0.3$ and intra-individuals with $p = 0.2$. Group B: analysis inter-individuals with $p = 0.5$ and intra-individuals with $p = 0.1$. After analysis of the angular kinematics it was possible to show that: it did not have an only standard of movement to carry through the postural change from quadrupedalism to standing position, in healthy young adults. Had strategies of elaboration and execution of movement that had shown similarity and little variability intra-individuals, however inter-individual had similarity between two groups, making possible to distinguish strategies specifies for accomplishment of the task.

Discrete Wavelet Analysis of Center of Pressure in Patients with Peripheral Vestibular Disorder

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Postural control is described as the result of the integration of extremely complex sensory systems (visual, vestibular and somatosensory systems). When the vestibular system is affected, the information is modified over the permanent postural accelerations, to which the man is submitted, a result of his interaction with gravity, needing more energy to keep his stance. *Objective*: To describe through a time-frequency analysis (Discrete Wavelet Transform - DWT) the behavior of the energy in the different frequency bands during the human bipedal stance in peripheral vestibular disorder patients. *Participants*: Twenty subjects were tested: 10 with peripheral vestibular disorder (29.6 ± 4.4 years old), whose etiology was a mild traumatic brain, and 10 healthy control (28.8 ± 3.8 years old). *Setup and Protocol*: A posturographic platform was used to evaluate the displacement of the center of pressure (CoP). The subject tested stood erect, with their arms parallel to the axis of the body. The duration of the test was 60 s (30 s with eyes open and 30 s with eyes closed). *Measurement and Analysis*: Anterior/posterior body sway was recorded. All signals were sampled at 40 Hz. The analysis was done with the DWT. The Daubouchies family of order 6 was used. The average energy for every frequency band was calculated between 4 and 0 Hz. Wilcoxon's test was used to correlate the average values for each frequency band in each test and for each group. *Results*: The significant numerical differences in both studied groups are much more noticeable in the low-frequency bands.
Open eyes: 1/16 Hz ($p < 0.0005$), 1/8 Hz ($p < 0.0009$), 1/4Hz ($p < 0.0065$).
Closed eyes: 1/16 Hz ($p < 0.0015$), 1/8 Hz ($p < 0.0019$), 1/4Hz ($p < 0.0065$), 1/2Hz ($p < 0.0082$).
Discussion: The principal differences were in the low-frequency bands. This implies that the visual system and the somatosensory system together are not capable of

completely controlling the lowest frequencies in the postural control and when we eliminate the visual information the frequencies below 1/2 Hz cannot be fully controlled. *Conclusions*: The vestibular system is fundamental in the control of the low frequency bands in the postural control in peripheral vestibular patients. The DWT analysis of the CoP could be an excellent tool to help in the diagnosis of vestibular pathologies and other postural disorders.

Organization of Muscle Modes and Synergies During Voluntary Body Sway

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We studied the coordination of muscle activity during voluntary body sway performed by human subjects at five different frequencies (0.125, 0.25, 0.50, 0.75, 1.00 Hz). Subjects stood on the force platform and performed cyclic anterior-posterior shifts of the center of pressure (COP) while being paced by the metronome. EMG of ten postural muscles were recorded (soleus, gastrocnemius lateralis, tibialis anterior, biceps femoris, semitendinosus, rectus femoris, vastus lateralis, vastus medialis, lumbar erector spinae, and rectus abdominis). A major question was: Does the makeup of muscle synergies and their ability to assure reproducible sway trajectory vary with the speed of the sway? Principal component analysis was used to identify three muscle groups (M-modes) within the space of integrated indices of muscle activity obtained from the EMG signals. M-mode vectors were similar across both subjects and sway frequencies ($p > 0.05$). The first M-mode was formed of dorsal muscles. The second M-mode was formed of ventral muscles. The third M-mode typically was formed of only a couple of muscles and varied across the subjects. There were also similar relations between changes in the magnitudes of all three M-modes and COP shifts (the Jacobians) across the sway frequencies ($p > 0.05$). Variance in the M-mode space across sway cycles was partitioned into two components, one that did not affect the average value of COP shift ("good variance") and the other that did ("bad variance"). An index (Delta-V) was computed reflecting the relative amount of the "good variance"; this index has been interpreted as reflecting a multi-M-mode synergy stabilizing the COP trajectory. The average value of Delta-V was similar across all sway frequencies; Delta-V showed a within-a-cycle modulation at low but not at high sway frequencies. The modulation was mostly due to variations in the "good variance." We conclude that muscle modes and their mapping on COP shifts are robust across a wide range of rates of COP shifts. Multi-M-mode synergies stabilize COP shifts (assure its reproducibility) within a wide range of its speeds, but only during cyclic COP changes. Taken together with earlier studies that showed weak or absent multi-M-mode synergies during fast discrete COP shifts, the results suggest a basic difference between the neural control assuring stability of steady-state processes (postural or oscillatory) and transient processes (such as discrete actions). Current results provide the most comprehensive support for the notion of multi-M-mode synergies stabilizing time profiles of important performance variables in motor tasks involving large muscle groups.

Hypotheses Explaining Why Diabetic Neuropathy Causes Postural Instability

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Diabetes mellitus is a metabolic disorder that is considered to be epidemic in modern societies given the increase in the number of diabetic patients every year. Diabetes can lead to neuropathy (damage to sensory and motor nerves) with complications for the person's physical and psychological life that also entail economic burdens for health care systems. A notable complication, mentioned in the literature, is postural instability. An unstable person can fall and have related complications and, perhaps most importantly, can lose their independence. There are now more than 30 research publications directed at the relation between postural control and diabetes since the first experimental investigation was conducted in 1982 (Mimori et al.). In those 25 years, all experiments have shown that diabetes per se is not the cause of instability. The question posed therefore is what factors lead to instability in neuropathy? Hypotheses already tested or only evoked in the literature are discussed in this poster. Symmetrical (left-right) peripheral sensory neuropathy has been proposed to be the cause of instability. This hypothesis, in fact, comprises three component hypotheses, all of which are evaluated. Is the neuropathy only symmetrical, only peripheral (i.e., not affecting the central nervous system), or only sensory (i.e., not involving the motor system)? Additional hypotheses are also considered, along with their supportive arguments: electrophysiological (e.g., different dysfunctions at the nerve conduction level), perceptual (e.g., detection of vibration or motion at the peripheral level), information processing (changes in the information and/or postural strategy used for postural control), biomechanical (the consequences of neuropathy for the dynamics of postural motion), and autonomic (issues at the heart rate level). We further consider methodological problems or confounding variables that might also explain why amplification of postural sway is symptomatic of diabetic patients with neuropathy. Finally, the ecological approach to perception-action is discussed. This framework has not yet been brought to bear, experimentally or theoretically, on this particular instance of impaired postural control. Suggestions are offered for how this approach might be applied to the results already found in the literature. (Acknowledgements: This research is supported by the Provost Grant.)

Postural Sway Variability During Precision Aiming in Parkinson's Disease Patients

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Previous research has shown that postural fluctuations can be adaptively manipulated independently in the anteroposterior (AP) and mediolateral (ML) directions when performing a precision aiming task. It has been identified that the sway in the AP and ML directions are reciprocally related. The present experiment looked at the postural fluctuations of patients with Parkinson's disease (PD) during the performance of such precision aiming tasks. We analyzed the variability of the center of pressure (CoP) under both feet during a 30 s precision aiming task. A laser pointer

was affixed to the hip of participants, and they were instructed to maintain the laser beam inside a target placed at varying distances (1 or 2 m), in either a parallel or perpendicular orientation to the body. Eight young healthy subjects, PD patients both on and off medication and age-matched elderly subjects, participated in the experiment. It was generally observed PD patients both on and off medication showed greater postural sway variability than healthy controls across all conditions in both AP and ML planes. While healthy subjects and to a lesser extent older adults showed modulation in the AP and ML sway patterns due to task demands, PD patients did not. Additionally, it was observed that sway variability was greater in patients on medication when the target was at a perpendicular orientation to the body compared to the parallel orientation condition. PD patients also showed an increase in ML sway variability and a decrease in AP sway variability while on medication across all conditions. PD patients in the "on medication" condition also showed greater sway variability when the target was placed at a 1 m distance than when the target was at a 2 m distance. The converse was true for patients in the "off medication" condition. These findings suggest that the experimental manipulation of a precision aiming task during upright standing induced the recruitment of different postural control strategies in PD patients when compared to healthy control subjects.

Influences of Delayed Visual Feedback on Balance Control

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Human postural control involves the integration of information from vestibular, visual, and proprioceptive sources, which update the CNS about the current state of both the environment and the body itself. The acquisition of sensory information from peripheral sources, however, does not occur instantaneously since transmission of information always requires a finite amount of time due to transmission delays and any intermediate processing. In general, time delays are well-known for their capacity to (de-)stabilize dynamical systems (Tass et al. 1996), such as the postural control system and its feedback integration. Previous research by Rougier (2004) has shown that short time-delayed visual feedback (250-300 ms) tends to stabilize the postural control system, while longer delays (> 300 ms) tend to increase the variability of the postural response. We performed an experiment in which we challenged postural stability in 11 healthy subjects with additional, artificial delays. Center of pressure (COP) data during quiet standing were collected under six different visual feedback conditions. A monitor at eye-height presented subjects with the location of their COP and they were instructed to position this representation of their COP as accurately as possible on a target within a defined boundary on the screen. Visual feedback of the COP was displayed either real-time, or delayed by 250, 500, 750, or 1000 ms. In a control condition, no visual feedback was provided. Subjects' COP trajectories exhibited oscillations around the target under all conditions. As expected, stability increased during real-time visual feedback compared to the case in which feedback was absent. With increasing delay in visual feedback, changes in amplitude and frequency of the postural response

were found. Interestingly, standard deviations across the four delay conditions were lowest for the 500 ms delay, most notably for motion in the mediolateral direction. Additional differences between the various visual conditions were seen in the analysis of mean-squared displacement, Hurst exponent and spectral characteristics of the COP signal, thus suggesting changes in dynamical organization of postural responses due to varying levels of time-delayed visual feedback. We can conclude that the extent to which subjects were coupled to the visual stimulus seemed to vary markedly and may hint at different strategies employed by the CNS during quiet standing. A model of postural control using stochastic delay differential equations is proposed in light of our results.

Balance Analyses in Post-Stroke Patients Presenting Hemiparesis Measured by Computerized Dynamic Posturography

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Introduction: Post-stroke patients having hemiparesis present difficulty in their daily life activities and fall risk due to poor postural control. This defective situation is characterized by altered temporal-spatial muscle contraction in the coordinated synergies and impaired sensorial references. They have in consequence poor muscle coordination during motor skills. *Purpose*: To identify balance changes in post-stroke patients presenting hemiparesis using a computerized dynamic posturography. *Methods*: Twenty-one volunteers, 12 independent walking post-stroke patients (mean age of 60 ± 6 years old), that could maintain the orthostatic position without support and 9 controls (mean age of 58 ± 8 years old) were submitted to the modified sensory organization test, which is a part of posturography protocol (ProBalance Master, NeuroCom). Their performance was compared in four different conditions: (1) eyes open – fixed support surface; (2) eyes closed – fixed support surface; (4) eyes open – sway referenced support surface and (5) eyes closed – sway referenced support surface. *Analyses*: Student's t-test for independent samples was used to compare the mean equilibrium score of each condition between the two groups and initial alignment of center of gravity (COG). Significance was considered $p < 0.05$. *Results*: There was significant difference in the equilibrium score at condition 5 ($p = 0.043$) and initial alignment of COG ($p = 0.018$). These patients showed less postural stability (37.47 ± 29.78) than controls (58.26 ± 11.55) resulting from a larger center of gravity's sway when standing quiet and a forward initial alignment of COG in this condition (post stroke patients COG "y" alignment = 2.165 and controls COG "y" alignment = 1.39). *Conclusion*: Walking post-stroke patients have difficulty in balance control in specific sensory or challenging conditions. This can explain the difficulties in their daily life activities and the increased number of falls. Physical therapy may focus balance and motor control to provide specific stimulus in this sense to complete motor function demand.

Analysis of the Dual-Task Paradigm: Attention Versus Maintenance of Posture in 7 Years-Old Children and Young Adults

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Purpose: The maintenance of posture and balance depends on musculoskeletal and neural mechanisms and mainly from their interaction. The visual, vestibular and somatosensory systems are responsible for the muscular adjustments that lead to balance. The dual-task paradigm has been used to demonstrate that the attentional demand can compete with cognitive functions. Based on this paradigm our study investigates if attentional demand can also compete with posture and balance control. *Relevance*: In rehabilitation routine we frequently expose patients to double activities involving the division of attentional resources and postural control (dual-task paradigms). We also expect our patients to develop the ability to perform dual-task activities without decreased performance. Although, we do not know precisely how normal individuals respond to attentional sharing during dual-task activities, also it is not clear if attentional division can be learned or improved. It is necessary to clarify what is involved in this paradigm and the compensations or adaptations of the motor system related to it. *Methods*: Nineteen 7 year-old non-pathological children and 38 normal young adults (mean age 23 ± 3 years old) were submitted to the Modified Sensory-Organization Test of Posturography (NeuroCom). Their performance was measured in two different equilibrium conditions: 1 - eyes open/stable platform, 4 - eyes open/unstable platform, each one with and without performing an attentional visual tracking task (COGNITIVO). The tracking task consisted of maintaining a circle, controlled with a joystick, inside a rectangle that was continuously and randomly moving horizontally on the computer screen, demanding attention, motor control and smooth pursuit eye movements. *Analysis*: Student's *t*-test was used to compare their balance performance under the different conditions. A significance level of $p < 0.05$ was used in this study. *Results*: All variable tests showed a significant difference with poorest performance for the 7 year-old children, including the time on target and equilibrium score in conditions 1 and 2 ($p < 0.001$ in all conditions test, with and without the second task). *Conclusion*: Our study showed that children achieved lower equilibrium and attentional scores than young adults during all test activities. Balance and attention functions need maturating process of musculoskeletal and neural mechanisms and it probably happens during all of the growing stage. Physiotherapists and other professionals must understand that children are still developing motor and attentional functions.

Influence of Sensorial Information on Static Balance of Community-Dwelling Elderly: A Comparison Regarding the History of Falling

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The processing of postural control starts with the environment and body communication, through sensorial systems. Because of aging, these systems are affected by the functional decrease and/or disease, predisposing the elderly to instability and falls. *Objective*: This work is aimed at analyzing the influence of sensorial information in the elderly's static balance comparing them in groups, according to the report of falls (without fall, one fall and recurrent falls) in the last year. *Method*: A cross-sectional descriptive comparative research. The sample was composed of community-dwelling elderly. Each group was reduced to 32 subjects by gender and age filter. The balance was evaluated with the Clinical Test of Sensory Interaction on Balance (CTSIB), which analyzes the stability maintenance capacity according to six sensorial conditions. The descriptive and inferential analysis was accomplished by means of the tests: Chi-squared, ANOVA and T-Test; with significance level of 0.05. *Results*: There was a larger number of CTSIB abnormal cases for the Group of recurrent falls in comparison to the Group without falls in the conditions 4 (p = 0.012) and 5 (p = 0.017); and to the Group of one fall in the condition 4 (p = 0.052). As for the time performance, the Group of recurrent falls remained less time than the Group without falls in the conditions 4 (p = 0.043), 5 (p = 0.042) and 6 (p = 0.052). In relation to the CTSIB progression, the Groups without falls and one fall presented less time from the condition 4 to 5 (p = 0.016 and p = 0.012, respectively); and the Group of recurrent falls had a worse performance from the condition 1 to 2 (p = 0.039) and from the condition 4 to 5 (p = 0.001). *Conclusion*: The results showed that the sensorial interaction in the elderly varies according to the history of falling. They also revealed that there is a larger dependence on the visual and somatosensory systems for the Group of recurrent falls. In this way, it is possible to guide the rehabilitation process and prevention with training and/or compensation of deficient strategies and decrease the sensorial dependence.

Functional Balance Evaluation of the Community-Dwelling Elderly According to the History of Falls

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Human balance is a complex motor task and its maintenance is essential to the accomplishment of daily activities. The aging process and chronic diseases that affect elderly people cause serious balance disorders, making them more sensitive to falls. *Objective*: To evaluate and compare the functional balance of three groups of community-dwelling elderly according to the history of falls. *Method*: A cross-sectional study was performed. The sample was comprised of 96 subjects, aged 65 or more who had been living in the community. They were divided into three groups according to the history of falls reported the year before. For the functional evaluation of balance the following instruments were used: Berg Balance Scale (BBS) and Timed Up and Go Test (TUGT). The descriptive and inferential analysis was accomplished by means of the tests: Chi-squared, ANOVA and Pearson Correlation; with significance level of 0.05. *Results*: The groups with history of one and recurrent falls spent more time in the TUGT than the group with no falls (p = 0.002). During the BBS evaluation, elderly people who presented recurrent falls scored less than those without falls (p = 0.013). A mild association was found between BBS and TUGT among the three groups (p = 0.000). *Conclusion*: The group with

falls, especially recurrent ones, presented more difficulty on the functional balance evaluation, which demonstrates the notorious influence of the balance deficit in the increase of the risk of falls in elderly people.

Anticipatory Postural Adjustments in Head Control

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We tested the hypothesis that reciprocal and co-activation APA patterns are defined by the type of perturbation applied to the head. We hypothesized that a local perturbation acting on the head elicits a reciprocal APA while a perturbation acting on the trunk and affecting the head indirectly elicits co-contraction APAs. We also explored a possibility that APAs in trunk and leg muscles might contribute to head stabilization to ensure a reliable reference frame during daily activities. Seven subjects performed fast up or down arm movements while standing. These movements were associated with mechanical perturbations acting predominantly on the head (HP), predominantly on the trunk (TP), and on the trunk and the head together (HTP). A customized helmet was used and a load was attached to it. The load either was moved by a short (HP) or long (HT, HTP) quick voluntary motion of the arms. EMGs of ten muscles were recorded: neck flexors (NF), neck extensors (NE), gastrocnemius lateralis (GL), tibialis anterior (TA), biceps femoris (BF), rectus femoris (RF), lumbar erector spinae (ES), and rectus abdominis (RA). Timing of activation within an agonist-antagonist muscle pair was assessed by cross-correlation analysis of EMGs. To evaluate the contribution of leg and trunk muscles to head stabilization, EMG signals for each muscle were integrated over the time interval -100 ms to +50 ms with respect to the movement initiation. Integrals were corrected and normalized for comparison across conditions. Reciprocal activation of NF/NE was observed under HP condition. Co-contraction was observed under TP and HTP conditions. We suggest that these different patterns are related to the predictability of the direction of the perturbation acting on the head. Predictable perturbations applied directly to the head were associated with reciprocal APAs organized optimally to minimize the effects of the head perturbation. However, under perturbations applied to the trunk, co-contraction of NF/NE was observed and interpreted as a mechanism of increasing the neck stiffness to a perturbation when its mechanical consequences are poorly predictable. The hypothesis that APAs in trunk and leg muscles contribute to head stabilization was falsified. Similar APAs occurred when perturbations were applied to the trunk and to the trunk and the head simultaneously, but APAs were much weaker or absent when the perturbations were applied to the head only. Leg/trunk APAs are more likely to contribute to head perturbation than to head stabilization.

Postural Oscillations in Response to a Muscle Twitch Caused by a Stimulus

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The main goals of the postural control system are: biomechanical alignment of the body, its orientation in relation to the environment, and balance. The maintenance of balance depends on the synergic activation of muscles bilaterally, and there is

evidence that spinal circuits under supra-spinal control mediate this coordination. Some methods have been used for the evaluation of postural control, but usually mobile platforms are used. Due to the high cost of this method, Hoffman and Koceja (1997), as an alternative, created a protocol of evaluation of dynamic balance through a postural disturbance provoked by a bilateral electric stimulation of the tibial nerve (TN). Our first goal is to enhance the yield of such a perturbation experiment by also recording the EMG of muscles from both legs in addition to force platform measurements. In addition, we adopted a single leg stimulation to allow the study of crossed reflexes. The subject stood on a force platform and the EMG of soleus, tibialis anterior, vastus medialis and semitendinosus muscles were recorded in response to a brief electrical stimulation applied to the right TN at the popliteal fossa. The joint angles in the sagittal plane were measured by a video system. Two experimental conditions were employed: the hip and knee angles were free (JNF) or fixed (JF) by fastening the subject to a wood panel. The objective of this study is to describe the neurophysiologic and biomechanic phenomena involved in the postural control of healthy subjects submitted to a muscle twitch provoked by an electric stimulus to the right TN. The contralateral effects of the perturbation probably include mechanisms of interlimb coordination. The preliminary data suggest that the EMG responses to the postural perturbation are higher in the condition with free joints (JNF) than with JF. The EMG pattern found in the soleus in the JNF condition was a reflex response (at 37 ms) followed by a period of inhibition that lasted 1 s. This pattern was not found in the JF condition. Moreover, the displacement of the center of pressure after the perturbation was smaller in the JF. These results could indicate that in condition JNF some EMG patterns were generated in response to movement of the knee and/or hip.

The Influence of Deprivation of Chosen Sensory Information On Whole Body Movements Characteristics—Speed and Accuracy Trade-Off Revisited

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Introduction. The main object of this study was comparison of fast voluntary movements performed by the whole body during standing in standard and modified sensory conditions. We assumed that deprivation of specific information from sensory inputs can modify the movement characteristic in such a way that Fitts' law could account for this movement. In this context the experiment was conducted in two different conditions to verify this hypothesis. *Methods*. Subjects stood barefoot on a force plate and performed rhythmic postural movements generating fore and back displacements of the center of pressure (shown as online visual feedback). Fitts-type task was realized by two groups consisted accordingly of 21 and 30 students of the Academy of Physical Education. Each subject in the first group was instructed to execute four series of oscillatory whole body aiming movements in the sagital plane. Thanks to the online visual feedback they were able to control the projection of center of foot pressure (COP) and reach designated targets. Each of four series differed in target distances. Subjects were instructed to move as fast and as accurately as they could. The second group realized the same task on a thick (10 cm) foam that was supposed to alter the sensory information inputs and produce the change

in movement characteristics. *Results*. Achieved empirical data indicate that in the examined group Fitts' law does not account for whole body movements executed in standard conditions. These results are in accordance with earlier researches. Introduction of a thick foam on a standing surface resulted in a significant change in the task execution. In the case of the second experimental group it was possible to describe the speed-accuracy trade-off as it is stated in Fitts' law. *Conclusions*. The observed phenomena could be an effect of inherent postural sway and movement sway. On the other hand the results of the second experimental group could be perceived as a result of more conscious movement control. In this way control of a postural movement is closer to the control of voluntary movement. It is also possible that the altering the surface sensory information changed the kinematic characteristics of movement and subjects were forced to produce higher moments and forces. Moreover one could have observed that the strategy of movement was changed from hip strategy to ankle strategy.

Balancing on the Movable Platform in Different Conditions—How Stable is a Strategy?

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Introduction. Performing some motor tasks, especially in high-performance sports, requires perfect interaction between the sensory and motor systems. The conviction that experts in acrobatics, gymnastics or dancing should have a great sense of balance is very common. The object of this research project was (1) to establish the effect of expertise in acrobatics on postural control and (2) to determine how stable is the strategy of movement control during balancing performance on a movable platform in different conditions. *Methods*. The research experiment was conducted on 11 high-level acrobats aged 21.3 ± 1.7 years and 22 students aged 21.1 ± 1.1 (control group). The subjects were examined using a stabilometer. The subjects were maintaining balance while standing on a movable platform of a stabilometer. The task was to keep balance standing on the stabilometer for 30 s while movements of the platform were affected by the person's behavior. Two parameters were calculated to characterize the dynamic balancing performance: instability (integral of average module of inclination) (degree/s), which were interpreted as a total error and balancing control (number of corrections), which describes a strategy of balancing. Balancing tasks were performed in A/P and M/L plane. All tests were carried out with and without visual control in both planes on the ground level and on the 50 cm high platform. *Results*. The achieved empirical data and its analysis allowed us to conclude that acrobats have significantly better balance control then students. Nevertheless very few differences were not statistically significant. Examined experts were better then students performing tasks 50 cm above the ground level ($p < 0.001$) and tasks with lack of vision ($p < 0.01$). Interestingly, the total amount of corrections was almost the same in all measurements in acrobats. It was observed that the amount of corrections increased in more difficult conditions in the control group. Values of average inclination and number of corrections were significantly correlated in students ($p < 0.05$). *Conclusion*. Practicing acrobatics contributes to

the development of specific postural control strategies, which is relatively stable in different conditions while balancing on a movable platform.

The Effect of Aging on Postural Control

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We analyzed the effect of aging in postural control during arms extension. The subjects were 12 healthy children (7-10 years old, children group), 11 young healthy adults (19-27 years old, adult group), and 10 old adults (over 60 years old, elderly group). The task was to perform with both arms as fast as possible a shoulder flexion holding an object with their hands. To avoid fatigue effects on muscle activity and preserve the posture perturbation effect, the object mass was different across groups (children 1 kg mass, adult 2 kg mass, elderly 1 kg mass). In addition, the adult group also performed the same task as they had to control a handheld laser pointer fixed on the top of their head. Each subject repeated the task 20 times. We measured the electrical activity of several muscles along the right side of the body (m. tibialis anterior, gastrocnemius lateralis, biceps femoris, rectus femoris, lumbar extensor, rectus abdominis, deltoid posterior and deltoid anterior), and shoulder angular kinematics. We used the principal component analysis on the set of muscle activity to reduce their dimension. Then, we applied the independent component analysis on the set of first 2 and 3 principal components and ran multiple linear regressions to analyze the relation between shoulder angular kinematics and the muscle independent components (mIC). We used ANOVA to study the effect of dimension on the RMS of the difference between the regression curve and measured shoulder kinematics. For children and elderly subjects, we found that RMS was lower with 2 mIC. On the other hand, young adults group showed lower RMS with 3 mIC. The aiming task did not affect RMS. As a consequence, if we consider that mIC are related to the motor common drive, the number of dimensions of the common drive is different due to aging. In conclusion, postural control during early and late human motor development stages showed similar behavior, while young adults presented a more flexible postural control.

Postural Control During Prolonged Standing in Persons with Chronic Low Back Pain

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Low back pain (LBP) is one of the most common causes of disability among workers of all ages. Several work-related physical activities have been frequently hypothesized to be associated with the onset of low back symptoms including lengthy periods of prolonged standing (Macfarlane et al., 1997; Mairiaux et al., 1996). Perception of discomfort related to prolonged standing is commonly assessed by LBP disabilities questionnaires (Baker et al., 1989; Kopec et al., 1996). However, there

are very few studies available concerning postural control strategies and adaptations during prolonged standing (PS), particularly in LBP subjects. Since changes in amplitude of postural patterns have been associated with response strategies that allow avoiding discomfort or fatigue during PS (Duarte et al., 1999; Freitas et al., 2005) it is expected that LBP subjects should have different postural strategies than healthy subjects during PS. Previous reports showed that LBP patients have altered postural control during quiet standing (della Volpe et al. 2005; Mientjes et al., 1999) or on a reduced base of support (Mok et al., 2004). In the present study, we carried out posturographic analyses of PS and quiet standing trials performed by chronic LBP subjects. Eight chronic LBP subjects (41.5 ± 18.4 years old; 1.75 ± 0.12 m; 77.4 ± 13.7 kg) were recruited from the chiropractic clinic of the university. Before the standing tasks, subjects were asked to complete a visual analog scale, the Fair-Avoidance Belief Questionnaire (FABQ) and the Oswestry Questionnaire. The experiment consisted of two tasks: 1) one 30 min of prolonged standing and 2) two trials of 60 s of quiet standing immediately before and after the first task. All standing trials were performed on a force-plate (AMTI). Forces and moments on the ground were recorded at a sampling frequency of 20 Hz to calculate the center of pressure (COP). The postural patterns during PS were quantified in the COP time history with the methods proposed by Duarte et al. (1999). COP summary measures, mean speed (Vcop) and root mean square (RMS) were also calculated. LBP subjects reported an average VAS score of 27.8 ± 22.6 mm and Oswestry Disability Index of 12 ± 9%. All LBP subjects were all able to stand for 30 min. The number and amplitude (median) of COP patterns during PS in M/L direction were respectively 30 and 14 mm for shifting, 14 and 33.5 mm for fidgeting and 10 and 10.4 mm for drifting. Low back pain perception seems to be related to the amplitude of postural changes. The results will be compared with those of previous reports.

The Isostretching Training Program in Adolescents with Cerebral Palsy

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Adolescents with cerebral palsy have a tendency to develop abnormal posture, attributed to muscle-skeletal alterations; however, there is a lack of publications on neurological patients' rehabilitation through posture alignment techniques. Isostretching is a posture program that works posture alignment, flexibility, strength and body consciousness, which are essential factors to good postural control. This research is a pilot-study with the purpose of evaluating the isostretching technique effects on spastic hemiplegia or diplegia cerebral palsy carriers, aged between 10 and 16. Four patients participated, two in the 10 session training program, with a frequency of once a week, and the other two patients in the 20 session training program with two therapies weekly. All patients had independent gait and proper comprehension. Posture alignment was evaluated through the Posture Evaluation Software SAPO (FAPESP), muscle strength through the Manual Muscle Strength Exam (Daniels, Williams & Worthinghan, 1986), muscle tone through the Ashworth Modified Scale (Bohannon & Smith, 1987) and range of motion through the Marques Goniometry Manual (Marques, 1997). The initial and final evaluation

of each participant was analyzed, and due to a small sample, the results were descriptively analyzed. It is possible to observe the muscle tone improvement in some muscle groups such as ankle flexors, knee extensors and flexors, hip flexors, adductors, and lateral rotator. There was also improvement in muscle strength, in most of all muscles groups of the lower extremities and all participants had a higher range of motion degree in the lower limbs' joints. A better posture alignment in several segments was verified, including pectoral arch, seen through a better horizontal alignment of the acromio and the scapula inferior border angle, in the pelvic arch the improvement was observed in the pelvis horizontal alignment and the postero-superior iliac angle, and in lower limbs the horizontal alignment of tibia tuberosity was also improved. The isostretching technique is a feasible treatment for postural alignment, muscle strength, muscle tone and range of motion improvement with short-term results.

Aging and Postural Control in Brazilian Sample: A Computerized Dynamic Posturography Study

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Introduction: Balance and postural control changes through life and they can be measured by posturography parameters such as center of gravity sway (equilibrium score) and sensory organization. The physiological deficits in sensorial organs and nervous system in older adults lead to increasing postural sway amplitude. These deficits happen in different ways and speeds, involving one or all sensory systems. Investigation of physiological deficits in the balance component of postural control is relevant for individual and population health. *Purpose*: To verify dynamic aspects of balance control during the normal aging process. *Methods*: Seventy-three non–pathological adults (age from 20 to 79 years-old) were submitted to the Modified Sensory-Organization Test. Balance dynamic computer-based posturography test performance was measured in four sensory conditions: (1) eyes opened/fixed support surface, (2) eyes closed/fixed support surface, (4) eyes opened/sway referenced support surface, (5) eyes closed/sway referenced support surface. *Analyses*: Pearson correlations were measured between age and equilibrium scores in all test conditions. Significance was assumed as $p < 0.05$. Significant correlations and tendency values were complemented with linear regression between the same variables. *Results*: Condition 1 and 2 equilibrium score did not present significant correlation. Condition 4 showed significant negative correlation values ($r = -0.374$, $p = 0.01$), with older adults presenting lower equilibrium scores. Correlation for condition 5 marked tendency values for the variables, representing also a negative correlation ($r = -0.203$, $p = 0.085$). Linear regression to condition 4 versus aging, on average established a loss of 0.19 equilibrium score in each year of aging. These can represent a total of 11.4 losses in numeric equilibrium score during 60 years of aging beginning in the 20s. To condition 5 these deficits represent 0.18 in equilibrium score for each year of aging. *Conclusions*: Our study is in agreement with the literature. Aging is associated with gradual and selective physiological

deficits in balance control caused by sensorial deficits and characterized by higher postural sway amplitudes. This knowledge gives us parameters to improve therapies involving balance control. These test conditions can evaluate individual postural sensory organization. We need to continue this study to permit the discussion within sensory organization scores.

Recurrence Quantification Analysis of Upright Stance with Postural and Respiratory Challenges

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During many activities, posture must be continuously regulated by the neuromuscular system to ensure stability. Information about the postural control system can be gained from ground reaction force center of pressure (CoP) kinematics. Traditional analysis methods use scalar measures of stability, which may give limited information about the dynamical organization of the postural control system, especially when considering CoP nonstationarity. In contrast, recurrence quantification analysis (RQA) makes no assumption about stationarity, and provides information about the structure and local dynamic stability of the postural control system. Regulation of posture does not occur in isolation but rather in concert with other physiological systems that could influence balance, such as autonomic respiration. We hypothesized that increasing system demands through either postural or respiratory challenges would stress the postural control system and elicit corresponding changes in the dynamics of the CoP. Ten subjects performed 2.5-min quiet stance trials under normal and challenged postural and respiratory conditions. The postural challenge was to maintain a 45-degree axial rotation of the trunk, while the respiratory challenge was manifested by having subjects breathe through a long narrow tube, increasing the dead space by ~1150 ml. Anterior-posterior (AP) and medio-lateral (ML) CoP time series were derived from ground reaction forces, sampled at 120 Hz. The state space was reconstructed from a 30-second record of each CoP time series by time-delayed embedding, followed by RQA analysis. Computed RQA variables assessed system repeatability (% determinism [%DET]), complexity (entropy [ENT]), and intermittency (% laminarity [%LAM]). The postural challenge resulted in changes in RQA variables for the ML CoP direction, such that %DET increased from 30.8 ± 33.1% to 45.4 ± 28.6%, ENT increased from 1.96 ± 1.57 bits to 2.73 ± 1.07 bits, and %LAM increased from 41.4 ± 33.6% to 58.1 ± 24.2%. The postural challenge produced no changes in the AP CoP. The respiratory challenge alone produced no changes in RQA variables. The postural challenge altered the orientation of the vestibular reference frame with respect to the base of support and, therefore, may have required a more complex integration of sensory and motor signals. Additional constraints may have been imposed on the postural control system by the trunk rotation, which increased the deterministic structure of the ML CoP and increased the tendency of the system to remain in specific postural states (decreased intermittency). (This research was funded by NSF grant BCS-0341767 and NIH grant R03AG026281-01A1.)

Postural Control in Blind, Legally Blind, and Sighted Adolescents

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A study was conducted to compare postural control in adolescents with and without visual impairments ranging in age from 12 to 18 years. The adolescents with visual impairments were selected from students attending a physical activity camp for children with visual impairments and were separated into two groups according to the classification of their visual impairment (B1s, total blindness and B3s, legal blindness). Prior to testing, all participants completed a questionnaire evaluating their self-efficacy of their balance. Participants were examined on both static (standing still, stability boundaries, tandem and one-legged stance) and dynamic postural tasks on a stabilometer (maximum lateral excursions and maintaining balance without platform motion). The results of the study showed that adolescents without visual impairments are more confident about their balance than the adolescents with visual impairments [F (3, 67) = 3.38, $p < 0.05$], and for the questions [F (16, 67) = 9.16, $p < 0.05$], however, no interaction was found. Not surprisingly, adolescents with visual impairments produced smaller stability boundaries and more postural motion during the standing still condition, tandem, and one-legged stances (total COP displacement and COP in the antero-posterior direction) than the sighted adolescents (p values < 0.05), however, no differences were found in the medio-lateral direction. B1s and B3s also moved with significantly greater variability than the adolescents without visual impairments ($p <$ 0.05) and required the use of the upper body to maintain stability. During the dynamic stability tasks, all groups oscillated at a similar frequency, however, the amplitude of motion increased as a function of group (p values < 0.05). It appears that the adolescents with visual impairments were freezing their degrees of freedom while oscillating on the stabilometer, while the adolescents without visual impairments were better able to coordinate their movements allowing for better control. In conclusion, although visual impairment was the most important indicator of performance during the postural tasks, the participant's self-efficacy and physical activity experiences were strong indicators for postural control in the adolescents with visual impairments. The fact that sighted adolescents performed better than the adolescents with visual impairments on all tasks, and all groups rated their balance ability as quite high, although VI participants were rated as significantly less, indicates that there is a strong need for balance interventions and increased physical activity in adolescents with visual impairments.

Standing on An Inclined Surface: The Effect of Light Touch On Sway

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Introduction: Previous work from this lab has shown that standing on a toes-up inclined surface leads to more sway when compared to horizontal standing and more so if there is no visual feedback. Other researchers have shown that tactile cues reduce postural oscillations. In the present work we intend to evaluate the improvements in sway caused by light touch when the subject is standing on a

horizontal surface or on a toes-up ramp, with or without vision. *Methods*: Seven normal male adults remained during 60 s over a force platform in both horizontal and inclined (14º upward) conditions. For both static positions two trials in each of the following conditions were performed: 1) eyes open; 2) eyes closed; 3) eyes closed with a light touch of the index finger over a fixed force transducer (vertical force on the transducer never exceeding 1 N). The RMS value of the detrended center of pressure (CP) signal in the sagittal plane was evaluated. The power spectral density (PSD) of the CP signal was estimated by the Welch method. Frequencies from 0.05 to 2 Hz were investigated. *Results*: There was a marked reduction ($p < 0.05$) of RMS values in condition 3 compared to condition 2 in both horizontal (43%) and inclined (31%) surfaces. The difference in the degree of sway reduction did not reach statistical significance. Additionally, in condition 3 there was a significant decrease ($p < 0.05$) in power at all frequencies tested, irrespective of surface inclination, compared to condition 2. The RMS values were smaller in condition 3 compared to condition 1, and in both surfaces, but the difference was significant only for the horizontal surface ($p < 0.05$). However, PSD values at frequencies lower than 0.2 Hz were higher in condition 1 compared to condition 3 ($p < 0.05$). *Discussion*: There were no changes in the capacity of postural sway reduction (caused by a tactile cue) in a condition of increased visual dependence (i.e., toes-up ramp). It suggests that the efficacy of the sensory cue in decreasing postural sway does not change when the subject goes from the horizontal to the inclined surface. Therefore, in a condition of increased visual dependence the light touch compensation was not changed. Nevertheless, the decreased power of the PSD of the CP in condition 3 compared to condition 1, at lower frequencies, points to an optimization of a long-term postural control mechanism.

Comparison of Sway During Kneeling and During Standing: A Spectral Analysis

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Introduction: Spectral analysis of the center of pressure (CP) signal has shown changes in different aspects of the control of balance in situations of altered sensory inflow. For instance, variations in the power spectral density (PSD) profile might indicate changes in short or long-term mechanisms of postural control. The present work investigated if changes in PSD profile found in upright and kneeling positions are due to alterations in postural strategies or are merely due to biomechanical factors. To reach this goal, besides the experimental approach, a biomechanical model was used to simulate postural sway in both upright and kneeling conditions. *Methods*: Eight normal male adults remained during 60 s over a force platform in upright or kneeling stances. A simple feedback-based biomechanical model in which the human body is represented by a single-link inverted pendulum was used. The neural controller was a standard PID (proportional/integrative/derivative) model. Sway patterns that resemble spontaneous sway obtained experimentally in both upright and kneeling (decreasing about 33% the height of the pendulum) conditions were generated. The PSDs of the CP signals (from both experiments and simulations) were estimated by the Welch method. *Results*: The spectra obtained in

both experiments and simulations, regardless of condition, were similar. The PSD obtained in the kneeling condition showed a substantial decrease in frequencies below 0.3 Hz compared to upright stance. On the other hand, there was a slight increase in the power at frequencies above 0.6 Hz. *Discussion*: The present results suggest that the observed spectral changes of the CP signals obtained from kneeling stance are mainly caused by biomechanical factors and not by alterations in some strategy or mechanism of postural control. Therefore, the central nervous system uses similar dynamics (or a similar "strategy") irrespective of the joint/muscles involved in the stabilization of the body. In spite of the simplicity of the biomechanical model (which uses only ankle joint angle as a feedback), the present work opens the possibility for further investigations through a more refined model that could incorporate vision and additional biomechanical elements (e.g., joint stiffness).

Controlling Human Upright Posture: Stabilogram Differences in Subjects Submitted to Army Training

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Introduction: In everyday life, in sports, in rehabilitation process, a common finding is the ability of the neuromuscular system to adapt in accordance with the specific task imposed on the subject. In the same vein, a question that we pose is if a training involving prolonged restricted upright posture can have enduring effects on the postural control system. As army recruits are submitted to training, which includes prolonged restricted upright posture, they seem to be the optimal population to test our hypothesis. The specific hypothesis is that such training leads to a decreased postural sway. *Method*: Thirty normal subjects were requested to stand upright over a force platform during 60 s. Twenty of these subjects were army recruits (AR) that had been under their initial 12 week training schedule. One of the activities of the training was a prolonged restricted upright posture during at least 120 min per day (uninterrupted). The other 10, which composed the control group, were healthy subjects (HS) not undergoing any specific motor training. Each subject normally performed two trials each, with eyes open (EO) or closed (EC). In order to avoid fatigue, each condition was performed at least with 1 min of rest between each trial. Parameters extracted from the center-of- pressure (COP), measured with a force platform, are taken as quantifiers of the spontaneous body motion. The data were analyzed by ANOVA two-way repeated measure ($p < 0.05$), considering the army training and the visual condition (Bonferroni-adjusted $p < 0.01$). *Results*: Three characteristics of the COP were considered in this work: RMS, mean velocity (MV) and mean frequency (MF). The RMS of the AR group was approximately 25% lower than that of the HS, and in the two groups the RMS had an increase during the EC situation, however it was not statistically significant ($p > 0.05$). The MV and MF were higher for the AR group ($p < 0.05$) suggesting a significant

dependence of these variables on visual and training condition. These results were similar in both directions (antero-posterior and medio-lateral). Considering only EO condition and using Student's *t*-test, we found considerable differences in the three parameters ($p < 0.001$). *Conclusion*: These findings showed that prolonged restricted upright posture training decreases sway, with concomitant increases in MV and MF parameters. These data suggest that the 3 months training was able to cause plasticity in the nervous system. Further research is under way to test the contribution of the spinal cord to this plasticity.

Age Related Changes of Compensatory Postural Adjustments in Typically Developing Children

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Postural control has been broadly investigated across different age groups and populations. However, few of the previous studies have explored the changes across the developmental course. This study aimed to investigate age-related changes of compensatory postural adjustments in typically developing children. Fifty-three children aged from 5 to 12 years old participated as subjects in this study. All subjects were right-handed and scored at or above the 30th percentile on Movement ABC test. The participants were asked to stand upright and still on a force platform and to perform a quick goal-directed arm movement with the right superior limb (shoulder flexion) towards a switch placed at the individual eye level at an arm's length away. Movement time and absolute errors from the arm movements as well as amplitude and changes in the center of pressure direction were recorded along the goal-directed arm movement performance. Regression analyses were computed in order to plot a developmental landscape. The results showed significant changes in compensatory postural adjustments and movement time parameters. As children develop significant changes in direction and amplitude of center of pressure, this suggests improvements in their ability to adjust and control their balance while performing voluntary arm movements by using feedback control strategies.

Age-Related Changes in Human Postural Control of Standing Tasks

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Introduction: The adoption of bipedal stance has profoundly affected human evolution. Ever since, humans have faced the challenge of balancing the body over a relatively small area of support. This challenge is apparent in the body sway that is always present while we stand. Aging is known to have a degrading influence on many structures and functions of the human body. The consequences of postural dyscontrol are typically severe; 30% of individuals older than 65 years old experience falls and falls are the leading cause of unintentional injury deaths for these individuals. It is common—but not ubiquitous—to find an increase in postural sway with aging when an individual is asked to stay as quiet as possible for a short period of time. However, there is at least one standing task where elderly

individuals show exactly the opposite compared to young adults: when we stand naturally—just like we normally do in our everyday life. During natural standing, continuous low-amplitude and slow swaying of the body is commonly interrupted by postural changes characterized by fast and gross body movements. *Objective*: The goal of this work is to better understand how young adults and elderly individuals stand for prolonged periods. *Methods*: Task: Natural standing (prolonged and unconstrained) for 30 min while watching TV. Seven young adults mean age 23 ± 3 years and seven healthy elderly individuals with mean age 69 ± 4 years stood on two force plates (one foot on each force plate). The following variables were analyzed: center of pressure (COP), base of support (kinematics of the feet); Mobility (Timed Up and Go test); Fear of falling (FES-I). *Results*: During prolonged unconstrained standing the elderly group exhibited increased postural sway compared to the young group. Both elderly and young individuals presented symmetrical performance as revealed by the asymmetry index (0.03 ± 0.47 and 0.03 ± 0.11, respectively). However the elderly group presented less postural changes during prolonged standing. *Conclusions*: Elderly individuals were able to stand for prolonged periods but they adopted a freezing strategy; they produced postural changes of lesser amplitude in comparison to young adults. The lack of mobility in elderly subjects may be responsible for the observed sub-optimal postural changes in this group and that the inability of elderly individuals to generate similar responses to adults during prolonged standing may contribute to the increased risk of falls in the older population.

Activation of Lateral Muscles Prior to Multidirectional Perturbation in Standing

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It is known that the central nervous system (CNS) uses activation of the trunk and leg muscles prior to the actual body perturbation to minimize postural perturbations. The majority of previous studies investigated the activation of the frontal and dorsal trunk and leg muscles in anticipation of a self initiated perturbation induced in sagittal plane. Only few studies were performed to investigate the organization of anticipatory postural adjustments (APAs) in muscles that maintain lateral stability of the body. Ten subjects were required to stand bare foot on the force platform in front of a size adjustable (1.1 to 1.4 m) aluminum pendulum attached to the ceiling. The pendulum was used to induce body perturbations in the frontal, sagittal, and oblique planes (intermediary position between frontal and sagittal planes). The subjects were required to look at the pendulum that was released by an experimenter and to stop it with their right or left hand. They were standing either facing the pendulum or when the pendulum was on the right or left side of their bodies. The EMG activities were recorded bilaterally from rectus femoris (RFR and RFL), biceps femoris (BFR and BFL), rectus abdominis (RAR and RAL), external obliques (EOR and EOL), erector spine (ESR and ESL), and gluteus medius (GMR and GML). A miniature accelerometer was attached to the pendulum to record the moment of perturbation associated with the pendulum being stopped by the subject's hand. The anticipatory integrals of EMG (IEMGs) were calculated during a 100 ms interval prior to the perturbation and then normalized.

The overall results showed anticipatory activation of the frontal (RFR, RFL, RAR, and RAL) and lateral muscles (EOR, EOL, GMR, and GML) while the dorsal muscles (BFR, BFL, ESR, and ESL) mostly demonstrated anticipatory inhibition. The magnitude of anticipatory IEMGs depended on the body position in relation to the perturbation direction. Specifically, the IEMGs of the EOR and EOL muscles were greater with the perturbation at the ipsilateral side and oblique planes (p = 0.03 and p = 0.00, respectively). For GMR and GML, the IEMGs were smaller when the perturbations were in the frontal. The results of the present study suggest that lateral muscles play an important role in feedforward postural control and their involvement depends on the orientation of the body in relation to the direction of the forthcoming perturbation.

Hemiparetic Stroke Balance Assessment Before and After Sensorial Stimulation of the Foot

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Purpose: To assess hemiparetic balance in individuals after a stroke, before and after motor and sensorial stimulation of the sole of the hemiparetic foot. *Method*: We studied 18 patients and they were randomized in three groups, the first one was submitted to sensorial stimulation (SS) in the plant of the hemiparetic foot with objects of different textures (marbles, small plastic balls, wooden foam, coil and supreme of beans, brush).The motor group (MS) received deep manual massage in the leg and in the plant of the hemiparetic foot, and the third group, the sensoriomotor (SMS), received sensorial stimulations through deep massage. The three groups had their exteroceptive sensibility evaluated with an estesiometer and the balance was evaluated with the PASS Scale (Post Stroke Assessment Scale), before and after the interventions. *Results*: We observed that for the isolated sensorial and motor stimulations in the sole of the hemiparetic foot, there was a significant increase in performance in balance when compared before and after interventions. We observed improvement in both groups, both in their sensorial level as well as in their balance. *Conclusion*: Sensorial stimulation or motor stimulation (used jointly or separately) promotes improvement in balance of hemiparetic individuals after a stroke.

Inter-modality Reweighting in the Postural Control

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Multisensory integration in the postural control system is crucial to maintain a flexible and stable upright stance. Recent studies have shown that abrupt changes in the environmental motion require dynamic adjustments in the weights of multiple sensory modalities. However, the properties of the sensory inter-modality reweighting remain unknown. Here we investigated the postural responses of two sensory

modalities measured simultaneously. Fifteen adults were placed in a virtual room and stood in a variable-pitch platform for thirteen trials. The surrounding visual environment and the platform were stationary in the first trial. In the following trials both visual display and platform were rotated simultaneously in different amplitudes and frequencies. The platform was rotated at constant frequency of 0.4 Hz and amplitudes of 0.3 and 1.5 degrees which were switched from two conditions: low-to-high and high-to-low amplitude platform motion. The visual stimulus was displayed at constant frequency of 0.35 Hz and amplitude of 0.08 degrees. The results showed that gain values were higher to the visual than to the platform stimulus. The coupling decreased to the platform motion but increased to the visual stimulus when the platform amplitude was increased indicating sensory reweighting in the responses of both modalities. When the platform amplitude was decreased there was no change in the gain weights to visual stimulus, however, upweighting responses were found to the platform motion. Smaller sway variability at frequencies other than the stimulus frequencies was observed when the platform oscillated at low amplitude. These results are consistent with the reweighting paradigm, except for the gain responses to the visual stimulus when the platform switched from high to low amplitude motion. While the platform motion was upweighted just after the switch, weights to visual stimulus changed slowly. These results suggest that the nervous system minimizes instability caused by sudden large support platform perturbations by rapidly decreasing the coupling to the platform motion and increasing coupling to the visual stimulus. However, upweighting is slow, possibly because it may be maladaptive to upweight quickly to any change in sensory conditions. Upweighting requires a sustained change in sensory conditions to insure postural stability. Indeed, how quickly or slowly the system adapts to the new sensory conditions depends on how the upright stance is threatened, suggesting a cognitive component to the reweighting process. The dynamics of inter-modality reweighting are an essential aspect of adaptive estimation in a continuously changing environment.

Correlation of Postural Alignment in Sagittal View and Postural Control

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Introduction: There are two functions of the postural control system which are fundamental for a healthy life: correct alignment of the body segments and adequate equilibrium. At first glance, one might expect that these two functions should be related, however, the data in the literature regarding this subject, although scarce, has shown that postural alignment and equilibrium control are not related. In this study the correlation between postural alignment from a sagittal view and equilibrium control have been investigated to better understand these two functions. *Method*: One hundred and fifteen individuals were evaluated (75% female) with mean age of 26 ± 7 years. The study took place in the Biophysics Laboratory at the University of São Paulo. After answering the anamnesis protocol and signing the

consent term, polystyrene markers were placed on specific anatomic points located on the head, trunk, and upper and lower limbs. A picture in the sagittal view was taken and analyzed with the free postural analysis software "SAPO" (http://sapo.incubadora.fapesp.br), specifically developed for this study. The X and Y coordinates of each anatomic point were determined and angles were calculated based on the analysis of the picture. A total of 11 pre-determined variables were considered to evaluate the postural alignment in the sagittal view. Postural control was investigated with a force platform through stabilographic analysis of quiet standing. The area of displacement and the average velocity of the center of pressure were used to quantify the equilibrium control. *Results*: The sagittal postural alignment of the sample was quantitatively evaluated using descriptive statistics for each of the 11 selected variables. None of them presented any significant correlation with the selected postural control variables. *Conclusion*: Methodology for quantitative analysis for possible correlation of sagittal body alignment and equilibrium sustains a lack of correlation between sagittal body alignment and postural control. This conclusion is supported by the use of SAPO software to evaluate body alignment and the use of stabilographic analysis to evaluate equilibrium. Evidence of correlation between sagittal body alignment and postural control was not present in healthy young adults. It is likely that the identified variability of the postural alignment measurements was inherent to the investigated phenomenon and further studies in individuals with disorders and significant asymmetries are suggested.

Motor Control Strategies to Maintain Balance in Elderly Subjects Evaluated Using Wavelet Transform

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Aims: Postural control is provided by complex interactions among proprioceptive, visual, vestibular and somatosensorial systems. Aging has been shown to affect all of these systems causing a poor balance in elderly subjects. The objective of this study was evaluate balance in elderly people using Wavelet Transform (WT) in order to provide a new tool to establish normal data for each gender in this population. *Methods*: Balance was evaluated in a probabilistic sample comprised of 50 males and 50 females with an average age of 78 and 77 years respectively using a posture platform device. The evaluation consisted of three phases. In the first phase, the subject was asked to maintain the center of pressure (CoP) in the base of support for 30 s while a visual feedback of the position of the CoP was provided through a computer screen. The second phase was similar to the first phase but the subject had to keep his/her eyes looking to the front without visual feedback, and the last phase was similar to the previous one but with eyes closed. Signals obtained from the displacement of CoP during the three tests for all subjects were analyzed by the Wavelet Transform in order to determine the intensity of each band (4 Hz, 2 Hz, 1 Hz, 1/2 Hz, 1/4 Hz, 1/8 Hz, and 1/16 Hz) for each gender. The Romberg index was calculated for each gender. SPSS software was used to evaluate differences in Romberg Index between genders. *Results*: Greater levels of total relative energy were obtained in men when compared with women with eyes closed and eyes open phases. Romberg Index had a normal distribution with a mean of 135.4 ± 41.9%. No significant differences in Romberg Index between females (124.2%) and males

(140.6%) were found ($p > 0.05$). However, there was a tendency for women to have lower Romberg Index values. *Conclusions*: Greater levels of energy obtained with eyes open as well as eyes closed in men could be understood as a difficulty to maintain balance due to a poor interrelationship among visual, vestibular and proprioceptive systems in elderly male subjects. Women obtained lower levels of Romberg Index which could indicate that women rely more on the visual system to maintain their balance. This could be associated with a major number of falls and fractures in elderly females.

Postural Responses Evoked by Platform Perturbations Are Consistent With Continuous But Not With Discontinuous Feedback

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Many researchers especially consider balance control as a process in which body sway is continuously fed back. Other researchers advocated alternative stabilizing mechanisms. The fundamental difference of the proposed alternative stabilizing mechanisms from the continuous feedback models is that the former are discontinuous. The goal of this paper is to quantify how much of the postural responses evoked by pseudo-random external periodic perturbations can be explained by continuous time invariant feedback control. Nine healthy subjects participated in this study. Center of mass (CoM) and ankle torque responses were elicited by periodic platform perturbations in forward-backward directions. Subjects had their eyes open (EO) or eyes closed (EC). The CoM and ankle torque recordings have been divided into periodic and non-periodic (remnant) components. Frequency response functions (FRFs) describing the dynamic behavior in the frequency domain were obtained from the periodic components, in this case from body sway to ankle. Finally, the remnants were analyzed to determine 1) whether the remnants originate from external measurement noise or from noise injected into the feedback loop, 2) whether the remnants are evoked by the perturbations or can be considered as spontaneous sway, and 3) at what location the noise enters the feedback loop in case the remnants originate from noise injected into the feedback loop. The periodic responses can explain most of the evoked responses, although the remnant power spectral densities (PSDs) were significant especially for slow responses (< 0.2 Hz) and largest for EC. The remnants were significantly larger than the PSD of body sway and ankle torques in unperturbed conditions (quiet stance), although the shape is similar. The found remnant PSD did depend on the sensory condition but not on the platform perturbation amplitude. From the correlation and ratio of torque and CoM remnants it could be concluded that the dominant noise source is at the input. Concepts found in literature that balance is controlled discontinuously or intermittently instead of continuously are not consistent with responses evoked by pseudo-random periodic platform perturbations. The found results are consistent with the concept that balance control is a continuous feedback mechanism in which variations in responses are due to noisy state estimation errors.

Postural Corrections in Response to Increasing Upper-Body Perturbations

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When a person is perturbed by an impact from behind, the body center of mass (CoM) will accelerate towards the anterior support boundary. To maintain stability without stepping, ankle plantarflexor torque causes the ground reaction force (GRF) center of pressure (CoP) to move quickly forward ahead of the CoM to decelerate the forward sway. Our goal was to examine the interaction between CoP and CoM motion during the ankle response to an upper-body perturbation, and to evaluate how these variables scale with perturbation level. While strapped to a lightweight moveable backboard in quiet stance, five young subjects were unexpectedly struck in the upper back with a swinging pendulum, causing forward sway. Subjects were instructed to resist the perturbation, and resume quiet stance as quickly as possible. Segmental kinematics and GRFs were measured with an 8-camera motion capture system and force plate. Initially, the pendulum was released to swing through a 10º arc before impact. The release point was increased in 5º increments to amplify subsequent perturbations, with trials continuing until the subjects stepped. The peak forward velocity of the CoM (dCoM/dt), peak forward rate of change of the CoP (dCoP/dt), and forward displacement of the CoM increased linearly with perturbation level. In contrast, peak forward CoP displacement changed nonlinearly. Above a threshold perturbation level, the CoP quickly moved forward to a constant position 27 ± 7 mm (mean ± s.d.) from the toes. The time that the CoP remained in this anterior position increased with perturbation level. At each perturbation level, the peak dCoP/dt was greater than the peak dCoM/dt (e.g., for highest perturbation level without stepping, peak dCoM/dt was 361 ± 58 mm/s and peak dCoP/dt was 1466 ± 315 mm/s). In quiet stance, large rapid CoP motion is viewed as a sign of instability. In contrast, to resist perturbations the ability to rapidly shift the CoP towards the support boundary and maintain its extreme position is highly desirable. The GRF force acting at the forward CoP position creates a stabilizing torque that decelerates the forward CoM motion. The forward distance the CoP can travel limits this stabilizing torque, and the rapid forward re-positioning of the CoP through plantarflexion aids in maximizing the desired angular impulse. Changes in mechanical properties of the plantarflexor muscles with disuse or aging may affect the rate of ankle torque development and the observed CoP strategy. (Funded by NIH grant R03AG026281-01A1 and NSF grant BCS-0341767.)

Muscular Work for Trunk's Extension in Erect Posture in People with Momentary Absence of Vision

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The maintenance of balance and of corporal orientation in human beings is granted by proper functioning of the sensorial system. Within the sensorial system we

find the visual system. When the visual information is not available for humans, vision's absence is compensated by adaptation with other senses. The aim of this work is to quantify the muscular work for doing the trunk extension movement in erect posture for people with preserved vision (PV) and for the same people with momentary absence of vision (MOAV). The research subjects consisted of ten men, healthy with average age (25.6 ± 2.26) years, average weight (68.22 ± 2.71) kg and average height (1.69 ± 0.25) m (mean ± SD). For the cinematic data acquisition the Hawk Digital system was used (Motion Analysis Corp., Santa Rosa, California) composed by eight synchronized cameras (200 Hz) that register, via infrared signal, the movement of reflexible spherical markers. These markers were positioned on the articulations of superior members (three per arm), inferior members (seven per leg) and in heads (three) of each person giving the movement of each body segment. Two force platforms (1000 Hz) were used in order to measure contact force of each foot. The EVaRT 5.0 program gives us the marker trajectory, since the mass center of each segment and of COM. By our own program developed within the MATLAB 6.5 (Mathworks, Inc.) environment, we were able to calculate the muscular work based on Arampatzis' (2000) method, for each one of the people of both groups. The results show a significant variance ($p < 0.05$) between the people with MOAV in comparison to the people with PV. The conclusion is that the visual information helps to minimize the muscular work used in flexion and extension of the trunk.

Asymmetry of Weight Bearing Between Hemiparetic Lower Limbs After Stroke

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Asymmetric weight bearing between hemiparetic lower limbs (AWBHL) is a common problem after stroke that implicate in functional disorders. *Objective*: To establish if there is a relation between AWBHL and factors such as muscular strength, joint movement amplitude (JMA), muscular tonus and lower-limb sensibility (LLS), and their effect on gait velocity. *Methods and Materials*: Twenty hemiparetic patients were involved in this study. The assessment of AWBHL was made with digital scales in two postures: static (feet parallel) and dynamic (feet in step position). Assessment of strength and tonus were made in hip extensor, knee extensor and ankle plantar flexor muscles based on Kendal and Ashworth scales, respectively. The ankle JMA and LLS were made with a goniometer and ankle position sense test, respectively. The gait velocity was recorded with a chronometer in a 10 m distance walking. The statistical analysis was made using *t*-test and multiple regressions. *Results*: There was a significant difference between lower members through the whole test. The paretic lower limb supported a smaller load. The ankle JMA and ankle plantar flexor strength had significant correlation with AWBHL ($r = 0.7$). There was no significant correlation between gait velocity and AWBHL. *Conclusion*: The ankle JMA and ankle plantar flexor strength were the main variables correlated to AWBHL.

Interaction Between Standing Balance and Upper Limb Rhythmic Activity

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The central nervous system employs control mechanisms in response to both external and self perturbations to prevent an individual from falling (or maintain stable upright stance). Previous work has shown that during a self-perturbation task involving arm swinging, one of two postural patterns between the lower limbs and arm emerge: a hip-shoulder inphase mode and an ankle shoulder inphase mode (Abe & Yamada, 2001). While the relationship between arm movement and the body's center of pressure has been studied (Ustinova et al., 2004; Forner-Cordero, 2005), the coupling within and between the elements of the lower limb have hitherto not been investigated. The purpose of the present study was to look at coupling in lower limb joints in response to a voluntary and repetitive upper limb perturbation, and examine sway patterns in response to the perturbing limb at various frequencies. To examine these issues 10 healthy subjects swung their arms inphase and antiphase in the anteroposterior direction to a metronome at frequencies of 0.67, 0.75, 1.0 and 1.5 Hz. Subjects wore reflective markers on their upper and lower limb joints which were recorded by an eight camera MX-40 Vicon motion capture system at 200 Hz. An AMTI force platform under each foot measured center of pressure (CoP) dynamics. A Hilbert transform was used to compute relative phase between the lower limb joints, and between the arm and CoP (arm-CoP) and the amplitude of the excursion of each of the joints. We observed that decrease in coupling between the hip, knee and ankle accompanied an increase in frequency of the arm swinging. The phase relationships between the elements of the lower limb showed relative phase values drifting further away from their stable state at zero degrees with increase in the arm movement velocity. This was true for both the in-phase and anti-phase arm swinging conditions. Asymmetries between left and right arm-CoP interactions were also observed at higher frequencies. As expected, the arm movements showed a drop in amplitude with increasing frequency. In the lower limb however a more complex pattern of results was observed. While hip and knee amplitudes increased with movement velocity, the ankle displacements remained relatively invariant. Our results provide insight into the existence of a task-specific control mechanism for the lower limbs during self-perturbations.

Arm Movements in Balance Maintenance and Recovery Based on Quantitative Balance Assessment

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Falls represent one of the most serious causes of injuries in the general population. Both the incidence and severity of injuries caused by falls are affected by environmental conditions and/or the person's functional or motor response abilities. Recent findings have shown that arm movements play a significant role in decreasing the center of gravity movement variability and thus play an important role in the body dynamics during balance maintenance tasks. Our study investigated the use of free arm movements in balance recovery when balance was lost as well as

for balance maintenance. The goal of the study is to examine and improve balance recovery and maintenance strategies and as such contribute to falls prevention. The experimental task required maintaining balance on a balancing board for experiments observing pitch and lateral balance separately. We have used three-axial accelerometers positioned on the arms, center of gravity and the balance board to quantify the observations. Segmentation of data into regions of stable balance and balance recovery regions was employed to examine arm movements in the two different regions independently. The analysis shows a significant increase in arm movements during the periods of balance recovery. Results of the analysis of variance demonstrate that during recovery of balance in both pitch and lateral directions, arm movements significantly increase. More specific comparisons based on the *t*-test analysis show significant differences in intensity of arm movement and demonstrate that dominant hands are significantly more involved in balance recovery. Review of the summary graphs and correlations between balance board and hand movements indicate different patterns of hand movements among participants with different scores on balance board maintenance. This indicates the difference in the motor abilities of different participants and the need for a classification of balance methods through future research. The results along with the other studies show that improvements in balance could be achieved through training of motor skills, specifically by rectification of arm movements.

Postural Control in Individuals with Anterior Cruciate Ligament Lesion

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After anterior cruciate ligament (ACL) lesion, performance of postural control is compromised, mainly, in those more challenging situations such as single-leg stance support. One possible explanation is that with ACL lesion, the afferent information from the injured leg is diminished and, therefore, the postural control would have the feedback mechanism affected. If this is the case, additional information would be able to enhance the performance of the system and even change its functioning. Therefore, the purpose of this study was to examine the mechanisms involved in the postural control functioning and the effect of the use of additional sensorial information in individuals with ACL lesion. Postural sway was analyzed in 28 young adults with ACL unilateral lesion (injured group) and in 28 young adults with healthy knees (control group). The participants stood on a force plate, in single-leg stance, with eyes closed, in four sensory information conditions: normal; infra-patellar adhesive tape; infra-patellar band; and touching a stationary surface (applied force below 1 N). Three trials of 30 s a piece were performed in each sensory condition. Center of pressure were decomposed into two trajectories: rambling and trembling (Zatsiorsky & Duarte, 1999; 2000). For

each trajectory, mean sway amplitude and predominant frequency were calculated, for both anterior-posterior and medial-lateral directions. Individuals with ACL showed larger sway variability of center of pressure than individuals with healthy knees. Similar results were observed regarding the rambling trajectory which was significantly larger than the trajectory of trembling. In addition, trembling showed high-frequency whereas rambling showed low-frequency. These results indicated that despite the compromised postural control performance, individuals with ACL lesion show similar mechanisms of postural control functioning when compared to individuals with healthy knees. With the use of additional sensory information, postural control performance improved in individual with ACL lesion with the largest effect observed in the touch condition. Based on these results, we suggest that reduction in postural control performance in individuals with ACL lesion would be due to the reduction of sensory information provided by the ACL but when sensory information is enhanced postural control performance is improved.

Postural Adjustment in Individuals Momentarily Deprived of Vision

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When an individual remains motionless, he or she does not remain without movement, as the body oscillates. An adjusted motor action requires integration and continuous regulation of multiple proprioceptive and vestibular information, in the normal condition and with lack of visual information. The purpose of this research was to quantitatively analyze the anticipatory postural adjustments (APA) and compensatory postural adjustments (CPA) of the trunk and inferior members' muscles through electromyography in individuals submitted to a momentary absence of vision. The movement task consisted of the following disturbance of the balance: fast extension of the trunk, starting at 90 degrees of flexion until upright posture. Kinematic and kinetic variables were used to locate the Instantaneous Point of Equilibrium (IEP) at upright posture. After the identification of this point, a window in the RMS data was selected to study the APA (tiep -200 ms) and the CPA (tiep +200 ms) caused by the auto-disturbance of the described movement of the muscles rectus abdominis (RA), lumbar ileocostal (IL), vastus lateralis (VL), semitendinosus (ST), tibialis anterior (TA) and lateral gastrocnemius (LG). The sample was composed of 10 male subjects, considered healthy, age 25.6 ± 2.3 years, 68.2 ± 2.7 kg and 1.69 ± 0.25 m (mean ± SD). These subjects performed the tasks with a momentary absence of vision (MVA) and also with preserved vision (PV). ANOVAs showed that there are statistically significant differences ($p < 0.05$) for both variables APA and CPA between the conditions MVA and PV. In the APA, significant differences had been found in the measures of RMS amplitude in the muscles RA, TA, and LG. CPA showed statistically significant differences in the muscles TA, ST and GL. During the MVA condition, such variation was more pronounced when it was compared to the PV condition. The preliminary results let us conclude that visual information is extremely important for modulating muscular activity during postural adjustments.

The Influence of Perception of Surroundings on Postural Control in Blind Children

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Postural control is subject to many internal and external disturbances. The stability regulation systems use some compensatory strategies when humans want to maintain stable upright posture in case of many different functional constraints. It is well known that information related to body stability comes from many sensory inputs, yet the dominant role is played by vision. It gives the most complete information on the conditions of movement execution and its possible changes. This research concentrates on the influence of perception of surroundings on postural control during both quiet stance and voluntary shift of COP in blind children. The experiment was conducted on 16 blind children aged from 15 to 16 years and 22 healthy children of the same age. The blind subjects had documented congenital blindness and no motor or other neurological disorders. The sway measured on the force platform was described by quantifying the change of position of the COP (center-of-foot pressure). The sway range (R) of COP displacements in (A/P) and (M/L) planes indicated the maximal deviation of the COP was used as a basic parameter describing the subjects' postural behavior. Additionally, the sway path length was recorded to characterize the quiet stance performance. Subjects were instructed to stand upright, barefoot on the force platform for 30 s. After quiet stance measurements, subjects were asked to make a maximal voluntary excursion test (MVE). Subjects were asked to make a maximal forward leaning after a 10 s of quiet stance and hold this position immobile as long as possible. Characteristics of the sway range (R_lean) of the average displacements of COP and average velocity of leaning phase (V_lean) from normal stance to maximal leaning position were used to evaluate quality of the control. Analysis of data shows statistically insignificant differences in variables describing quiet stance ($p > 0.05$). Considering the maximal voluntary excursion test the level of the difference in sway range was also insignificant ($p > 0.05$). It should be noted that blind subjects were familiar with their surroundings. There were statistically significant differences in velocity of voluntary leaning ($p < 0.001$). The process of postural control is influenced both by information system and psychological aspects. Results allow us to assume that lack of vision could be substituted by sensory inputs from proprioreceptors and from the vestibular signal in blind subjects during the assessment of static balance. Perception of surroundings seems to be an important factor that influences that phenomenon although the strategy of stability control during voluntary excursion significantly differs in the compared groups.

Effects of Sensory Stimuli on Postural Control: Case Study of a Tetraplegic

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Introduction: The sensory stimulus plays a fundamental role in postural control in all subjects. A close relationship exists between sensorial and motor mechanisms to control the static and dynamic posture. For this reason, diverse authors indicate

that postural control is a sensory-motor conduct involving the activation of diverse sensorial receptors; we cannot forget the visual and vestibular influence. The sensorial stimuli make feedback with motor neuronal circuits at level to medular contributing to postural control. But, when there is a total or incomplete marrow section, it affects the sensory mechanisms and then motors, provoking a permanent alteration in the postural control. *Objective*: To analyze if specific manual sensory stimulus (SMSS) can generate changes in the postural control in a subject who has suffered an incomplete spinal cord section at the fifth cervical vertebra (C5) level. *Method*: Tetraplegic patient, 21 years old, with incomplete spinal cord section at C5 level. According to ASIA, he has a 33 motor-score and 10 sensory-score. He receives SMSS (465 days after spinal cord section) in decubitus dorsal, ventral and lateral position for 60 min. The patient is evaluated in static-posturographic-platform in sitting position before and immediately after the stimulation. Signals obtained from the displacement of center of pressure during the test were analyzed to determinate values of total relative energy (RTE), area and peak velocity of pressure center displacement (DCoP). *Results*: Lower levels of RTE were obtained in the second evaluation when compared with the first evaluation with eyes open (0.0217 – 0.009 au) and eyes closed (0.091 – 0.069 au) phases. Lower DCoP area was also obtained (35.7 – 17.8 mm^2) and (265.8 – 137.6 mm^2) respectively. Greater increase of the DCoP peak velocity was found in the closed-eyes phase (0.228 – 0.419 mm^2/s). *Discussion*: The lower levels of ETR obtained with eyes open as well as eyes closed could be understood as training or improvement in maintaining balance at reflex/automatic levels. This would be due to lower levels of energy in low frequency bands, an increase of peak velocity in closed-eyes phase and the lower DCoP area post-stimulation. Therefore SMSS could indicate an improvement in the postural control in a tetraplegic through the activation of receptors of low threshold (mechanic and propioceptive) that act at involuntary levels to improve the body posture in space, firing the activation of diverse descending unharmed circuits that would make these adjustments.

Locomotion

The History of Foot Ulceration Does Not Change Lower Leg EMG Activity During Shod Gait in Diabetic Neuropathy

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The purpose of this study was to investigate the influence of diabetic neuropathy and history of plantar ulcers in electromyography activity of thigh and calf muscles during shod gait using habitual shoes. This study involved 45 adults divided into three groups: control group (CG; $n = 16$), diabetic neuropathic group (DG; $n = 19$) and diabetic neuropathic group with previous history of plantar ulceration (UDG; $n = 10$). All neuropathic subjects were diagnosed by physicians. The electrical activity of the right vastus lateralis (VL), gastrocnemius lateralis (GL) and tibialis anterior (TA) were studied during stance phase of a self-selected cadence gait. The bipolar surface electrodes were placed according to SENIAM recommendations. Electromyography was collected simultaneously with the ground reaction force

(GRF), which was used to synchronize and to determine the stance phase of each subject. The EMG variables calculated from the linear envelopes curves were: the maximum peaks and time of peak occurrence for TA, VL and GL muscles, and a co-activation index calculated by the ratio between TA and GL IEMG. Inter-group comparisons of electromyographic variables were made using two MANOVAs (peaks and times) and one ANOVA-one way for the co-activation index between the TA and GL. An $\alpha < 0.05$ was adopted. UDG presented the time of GL peak occurrence delayed in comparison to CG (CG = 65.56 ± 3.95; DG = 67.32 ± 3.33; UDG = 70.20 ± 4.87; $p = 0.02$). The co-activation index was significantly higher in CG in comparison to both diabetic groups (CG = 0.97 ± 0.04; DG = 0.94 ± 0.03; UDG = 0.93 ± 0.04; $p = 0.02$). There were no other statistical differences. The delayed activity of GL on the UDG could be an indicative of a propulsion inefficacy in diabetic neuropathic subjects with worse clinical history represented by the plantar ulcers occurrence. This alteration could be responsible for the lower ankle extensor moments on push-off phase in neuropathic subjects, which is already described in the literature. The higher co-activation index in the CG subjects indicates better ankle stability in healthy subjects when compared to diabetic neuropathic subjects. Although they showed smaller co-activation mechanisms and a probable deficit of the propulsion mechanisms, which could compromise their ability to walk, the diabetic subjects did not present any changes in the activity of the muscles responsible for load attenuation during the initial contact of the foot with the floor (TA and VL), which is described in the literature as one of the mechanisms to avoid foot ulceration. Muscle activity mechanisms to load attenuation did not occur when diabetic neuropathic subjects walk with their habitual shoes, once its use attenuates loads in the diabetic foot.

Does Legged Locomotion Yield a Gait-Invariant Measure of Distance?

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We investigated whether the haptic information generated during legged locomotion provides a measure of distance. Specifically we asked: In the absence of vision and hearing, is a given distance identical when measured by various gait styles? In Experiment 1 participants wore a blindfold and noise-canceling headphones and either walked or jogged from a starting point A to an end point B, signaled during locomotion by the experimenter. The task of the participants in each trial was to replicate, by walking from B, the previously traveled distance A-B. In concert with the findings of Schwartz (1999), the results of Experiment 1 suggested that successful distance replication was not based on either the number of steps from A to B, the duration of travel from A to B, or auditory and tactile landmarks. Experiment 2 replicated the design of Experiment 1 but with so-called "gallop-walking" rather than jogging. The gallop-walk is characterized by repetition of the rule "step forward with the right foot, then bring the left foot into alignment with the right foot and pause." Results showed that participants accurately replicated the outbound distance in the walk condition but significantly underestimated the outbound dis-

tance in the gallop-walk condition. Given the demonstrated indifference of distance replication to the type and speed of gait used from A to B (Experiment 1; Harrison, 2007; Schwartz, 1999) the contrast between gallop-walk and walk is anomalous. All non-walk gaits used in A to B travel to date have been of like symmetry: both legs do the same thing, ½ period out of phase with each other, continuously. The gallop-walk has a different and lower symmetry (Pinto & Golubitsky, 2006). The next round of experiments will investigate whether the symmetry of locomotion as a distance-measuring system is a determinant of the distance measure.

Changes in Muscle Activity With the Addition of Gait Initiation After Standing Up from a Chair

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Although gait initiation from an upright posture has been extensively studied, little attention has been given to understanding gait initiation from a sitting posture. The purpose of the present study is to describe the changes in muscle activity during STW movement in comparison to STS movement. A green light cued individuals ($N = 7$) to initiate a sit-to-walk (STW) movement whereas a red light cued them to perform a sit-to-stand (STS) movement. Participants sat on an armless and backless seat with a mechanism for adjusting seat height (based on knee distance from the ground). They kept arms folded on the chest throughout the trial and were instructed to stand up as quickly as possible and to initiate gait with the right leg. Ten channels of EMG were recorded using surface electrodes over the belly of tibialis anterior (TA), medial gastrocnemius (GA), rectus femoris (RF), biceps femoris (BF), and erector spinae at L3-L4 location (ES). EMG signal was full wave rectified and digitally filtered using a fourth-order zero lag Butterworth filter with a cut-off frequency of 10 Hz. Six markers were placed on anatomical landmarks on the right side (5th metatarsal, heel, ankle, knee, hip and shoulder) and tracked by three OPTOTRAK units. A force plate was used under the seat to identify seat-off event. EMG data was aligned relative to the movement initiation (identified based on the anteroposterior velocity profile of the shoulder). EMG profiles for the STS movement (plus/minus one standard deviation) were used as baseline values. For the STW, deviations from this baseline values were identified and the latencies were calculated. The results indicated that for right and left TA, changes in muscle activity started before seat-off, which can be interpreted as an additional mechanism to help move the body forward. For the muscle latencies, the one-way ANOVA with repeated measures (muscles) identified a main effect [$F(9,54) = 5.795$, $p = 0.006$]. Differences between left and right pairs of muscles were observed only for the GA (longer latency for the left than for the right side) due to differences in timing for the right and left push-offs. For the right side, changes in the TA, GA, and RF were followed by changes in the ES and later by changes in the BF. For the left side, changes in the TA were followed by changes in the RF and ES and later by changes in the GA and BF.

Walking and Running in Children from Three to Six Years Old

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Introduction: Spatio-temporal parameters change at different gait velocities. Describe gait parameters in different speeds, and what strategies children use to increase speed is important when studying gait development maturation. *Purpose*: This study described and compared spatio-temporal data during walking (slow, self-selected, and fast) and running in children from three to six years old. *Methods*: Twenty healthy children (10 boys and 10 girls) participated voluntarily in this study. Spatio-temporal data was assessed using two synchronized video cameras at 60 f/s. Three trials were obtained from each child. Children completed 10 m in the laboratory using the following sequence: 1) self-selected walking, 2) slow walking, 3) fast walking, and 4) running. Lateral malleolus marker was digitized. DLT method was used to calculate 3D coordinates. Repeated measures ANOVA was performed to compare stride length, cadence and single support time between speed groups. A significance level of 0.05 was used. Stride length was normalized by leg length. *Results*: The results are as follows. Velocity: Significant differences ($p < 0.01$) among all speed walking (slow: 0.90 ± 0.26 m/s; self-selected: 1.16 ± 0.22 m/s; fast: 1.49 ± 0.26 m/s) and running (2.64 ± 0.52 m/s). Stride length (% leg length): Significant differences ($p < 0.01$) between running (2.26 ± 0.38) and all other groups (slow: 1.33 ± 0.28; self-selected: 1.48 ± 0.16; fast: 1.59 ± 0.14), and between slow and fast walking groups. Cadence: Significant differences ($p < 0.01$) among all speed groups (slow: 128.39 ± 21.29 step/min; self-selected: 150.70 ± 23.29 step/min; fast: 178.78 ± 24.71 step/min; running: 223.36 ± 20.4 step/min). Single support time (% cycle): Significant differences ($p < 0.01$) between running (12.96 ± 6.34) and all walking groups (slow: 35.40 ± 4.33; self-selected: 37.20 ± 3.29; fast: 41.69 ± 4). Fast speed group single support time was higher when compared to the self-selected and slow groups ($p < 0.01$). Furthermore, higher variations were found in running and slow walking for stride length and single support, but not for cadence. *Conclusion*: This study provided spatio-temporal parameters data for running and walking at three different speeds. Results suggested that cadence, followed by stride length, is an important factor to improve gait speed in children from three to six years old.

Variability of Neuromuscular Mechanisms and Gravitational Torque in the Initial Stages of Independent Gait in Typically Developing Children

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Introduction: The use of neuromuscular mechanisms has been considered an essential component in the process of motor acquisition. In general, periods of variability are important because they characterize an exploration phase of the different systems, making possible the selection of future adaptive strategies. *Aim*: Evaluate the longitudinal changes of the variability distribution of the co-contraction indexes (CCI) and the gravitational torque (mLg), within-children and between children, during the period of 2 months after gait acquisition in typical children. *Methods*: Twelve children with typical motor development were followed during 2 months after onset of independent gait. Quantification of the EMG signals of six muscles in the right lower limb allowed the calculation of the CCI considering pairs of antagonistic muscles, representing the hip, knee and ankle joints, and the sum of the CCIs yield a total index. The initial period of gait acquisition was documented by the Alberta Infant Motor Scale standardized test, and the anthropometric measurements were transformed into gravitational torque (mLg) for the stance and swing phases of gait. For the data analysis the normalized variable was used (CCI/mLg). Statistical analyses included a regression model for longitudinal data to evaluate the variability within-children and between children of the variables mentioned above, in both phases of gait. *Results*: The regression model demonstrated significant differences between infants in the CCI/mLg from all joints, in the total CCI/mLg, and in the mLg ($p = 0.0001$), during stance and swing. The variance partitioning revealed proportionally greater variation within-children than between children in the hip and ankle CCI/mLg, during stance, and in all joints during swing. *Conclusion*: The results of this study demonstrated that the period of 2 months after gait acquisition was characterized by great variability in the use of neuromuscular mechanisms illustrated by the co-contraction indexes in the lower extremities. This variability was relatively greater between children, in the CCI/mLg of the knee and total indexes, in the stance phase of gait, compared to the variability observed in the same child through the longitudinal period. During the period of the study, the children presented different gravitational torques in the lower extremities and also relatively greater variability in the individual use of neuromuscular mechanisms of the hip, in stance and swing phases of gait. These results suggest that the process of exploration and selection of motor patterns by typical children is characterized by great variability of individual strategies on neuromuscular mechanisms.

Heel Contact Changes During Walking According to the Restricted Surface

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Most falls among the elderly occur during walking. Changes at heel contact with the ground during walking indicate gait instability and increased risk of falls. Related to gait instability, it is important to study gait changes according to the surface features. In order to contribute to better understanding of balance during walking, especially related to the aging process, the aim of this study was to investigate changes in the horizontal velocity and the ankle dorsiflexion angle at heel contact

in elderly and young adults during walking with surface constraints. The gait patterns of 7 elderly (69.4 ± 2.9 years of age) and 7 young adults (23.3 ± 2.3 years of age) were analyzed over an unconstrained surface (UCS) and under two more conditions: over a narrow constrained surface (NCS = 19 cm width) and a narrow and high surface (NHS = 19 cm width and 10 cm height). A digital camcorder recorded a gait cycle at 60 Hz in the sagittal plane by means of the trajectory of reflexive markers attached on the following right lower limb anatomic points: fifth metatarsal, calcaneus, lateral malleolus and lateral condyle. Dvideow 6.3 software was used for the photogrammetric procedure and Matlab version 6.5 to calculate the dependent variables. A MANOVA (2 groups × 3 conditions), with repeated measures for condition reveals only condition main effect [Wilks Lambda = 0.346; $F(9,4) = 4.249$; $p < 0.034$]. Univariate analyses showed differences for horizontal velocity [$F(15,1) = 6.710$; $p < 0.016$] and ankle dorsiflexion angle [$F(24,2) = 7.051$; $p < 0.005$]. Post hoc tests revealed decreases in horizontal velocity ($p < 0.047$) at NCS (0.14 + 0.06 m/s) related to UCS (0.22 + 0.12 m/s), and a trend ($p = 0.06$) at NHS (0.12 + 0.06 m/s) related to UCS. For the ankle dorsiflexion angle, post hoc tests revealed a decrease ($p < 0.026$) at NCS (118.75 + 4.79º) related to UCS (120.11 + 4.59º). Since the elderly participants were not considered fragile (no advanced age and no history of falls), we could not show differences between groups. On the other hand, the surface constraints produced changes in the gait pattern indicating caution during walking in order to compensate for the narrow base of support and to increase stability. The ankle dorsiflexion angle is an important variable to measure stumble avoidance, as reducing it can promote better stabilization during NS condition, the most perturbed condition. Thus, such gait deficits are indicative of performance difficulties because they can be predictors of risk of falls.

Use of Neuromotor Strategies by Typically Developing Children and Children with Down Syndrome During the Development of Independent Gait

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Motor development involves learning to convert a high-dimensional system into a controllable system. In this process, children learn to use the available resources and to modulate their spontaneous movements to meet the task's goals (Goldfield, 2000). Children with Down syndrome (DS) have musculoskeletal characteristics, such as hypotonia, that differ from typically developing children (TD). Nevertheless, they acquire basic motor milestones at a later age. This study compared normalized indices of lower limb's stiffness and co-contraction (CCI) used by TD children ($n = 12$) and children with DS ($n = 12$), during gait acquisition. Five longitudinal evaluations of children were conducted from the onset of independent locomotion until 3 months post-acquisition. All children were videotaped and had EMG recordings, which were used to calculate CCI of hip, knee, ankle and total leg CCI. Leg stiffness was calculated by equations of movement (Holt et al., 2000; Fonseca et al., 2001). Indices were normalized by gravitational torque in swing and stance phases of gait. Results from MANOVA revealed no group differences on stiffness or on CCI during stance, but children with DS showed greater CCI

during swing. Despite hypotonia, children with DS presented more similarities to TD than differences in the processes of gait development.

The Use of Dynamic Gait Index in Patients with Peripheral Vestibular Disorders

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Patients with peripheral vestibular disorders suffer from balance problems during gait and a high incidence of falls is observed in these patients. *Aim*: To evaluate dynamic balance during gait in patients with peripheral vestibular disorders. *Methods*: Twenty-three patients, of both genders, age from 14 to 81 years old, with peripheral vestibular disorders were submitted to the Dynamic Gait Index (DGI) test. For statistical treatment we used the Kolmogorov-Smirnov and Kruskal-Wallis tests with a significance level of 0.05. *Results*: Nine patients (39.13%) presented low scores in the DGI test which indicated gait alterations. *Conclusion*: An important parcel of patients with peripheral vestibular disorders suffers from balance problems during gait.

What Is the Effect of the Use of Baby Walker on Motor Development of Typically Developing Children?

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Introduction: The walker is equipment frequently used during the period before the acquisition of independent gait in typically developing children. Some parents utilize this equipment because they believe that it helps their children to walk independently. There are studies, however, that warn against the use of baby walkers, as the authors argue that they may be responsible for delaying the acquisition of locomotor milestones in children. *Aim*: To critically review the literature to respond to the following question "What is the effect of the use of baby walker on the motor development of typically developing children?" (Critically appraised topic – CAT). *Methods*: Four databases, Medline, Lilacs, COCHRANE and SCIELO, were searched in November 2006 using the key words: baby-walkers OR walkers AND motor development AND infants. *Results*: Twenty articles were found in Medline, 1 unpublished study at the COCHRANE, 3 in Lilacs and none in SCIELO. Of these, 4 contained in the title and the abstract aspects that concerned motor development using baby walkers and were possible to be located by the portal CAPES. In addition, a search of the reference list of these articles was conducted and, at the end, 6 articles were reviewed in this CAT. All the studies argued against the use of baby walkers during the motor development period, because this equipment can delay or alter the achievement of locomotor milestones. Almost all the studies referred to a very premature use of walkers (i.e., between 4 and 5 months of age) and none

controlled for walker exposure. Additionally, almost all studies had a cross-sectional study design, which cannot inform us about future motor development, but can respond to the question of at what age the child acquired some motor milestones. The studies that had a longitudinal component, only studied the children up to the onset of independent walking, and not after that. The studies, overall, show poor methodological quality, the number of participants seemed to be small and only one study presented sample size calculation, there was no information regarding the validity and reliability of almost all the instruments used to measure the outcomes, and the intervention (i.e., use of baby walker) was not controlled and systematized (i.e., parents reports). *Conclusion*: There are no definite conclusions about the real effect of the use of baby walkers on the motor development in typically developing children. All studies reviewed had methodological failures, encouraging new studies in this area.

Reduction in the Reflex Latencies of the Rectus Femoris During Gait Perturbation Experiments

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Reflex mechanisms play an important role for stabilization during gait. For large perturbations, reflexes with longer latencies result in adequate reactions to the perturbation. Latencies might be shorter, and the risk for falling might decrease, if the reaction is practiced, e.g., through a sequence of experimental perturbations. The goal of this study is to test if reflex mechanisms might change during a session with multiple perturbations. An experimental setup simulated stumbling during treadmill walking based on stopping the swinging movement of the leg by means of a rope attached to the lower left leg. A pneumatic device could block the rope at desired instants with respect to the phase of the gait cycle. Four healthy subjects were walking continuously on a treadmill at 4 km/h when an unexpected perturbation at early swing was applied. Kinematic responses of the lower limbs were recorded along with the EMG of the Rectus Femoris (RF) of the perturbed leg. The electrode placement followed the SENIAM recommendations. The markers data were smoothed and joint angles were calculated. To assess the changes in response times, the gait timing events (instants of heel-strike and toe-off) were computed. The surface EMG was rectified and filtered recursively to avoid time-lag with a cut-off frequency of 30 Hz. Differences in the recovery reaction performed at the beginning and at the end of the experimental session, after the participants experienced more than ten perturbations, were analyzed. The latency of the burst in the Rectus Femoris (RF), measured with surface EMG (sEMG), showed a significant reduction during the course of the experimental session. No EMG amplitude reduction was noted. Recent work showed that the RF plays a major role controlling the stance to swing. The major conclusion is that the subjects learned from the first perturbation trials improving their responses during the experimental session.

Behavior of Body Center of Mass During Walking in Water

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Water based exercises have been largely adopted in rehabilitation programs. Among them, walking in water is one of the most popular, since it can be attempted by patients of all ages and with most medical conditions. For this reason, biomechanical characterization of walking in water have been done by investigating joint angles, joint moments, ground reaction forces and electromyographic activation patterns. Despite this, very little is known about motor control strategies employed by the central nervous system (CNS) during walking in water. Consequently, it is difficult to predict the effect of underwater walking on patients with motor disorders related to posture or balance control. It is well known that control of body center of mass (BCOM) during gait is strongly related to posture and balance. In this sense, examination of the BCOM displacement during gait provides information about dynamic stability control and CNS strategies to achieve it. Therefore, the aim of this work was to investigate the behavior of BCOM during walking in water, comparing its characteristics with those on dry land. To do this, 19 healthy male adults were videotaped while walking at self-selected speeds on land and in water at the Xiphoid-process level. Markers were placed over anatomical landmarks, their coordinates were recovered and position of BCOM was calculated through a segmental analysis method. Beside the usual BCOM characteristics such as vertical excursion and horizontal velocity, the horizontal distance between the BCOM and the point of support was calculated. During the single stance phase, such distance provides a measure of stability. Among the results, it was possible to observe differences between the form of BCOM's trajectory in water and dry land. This property might indicate that the interchange of potential and kinetic energies is different in the water environment. Another result is that the BCOM remains farther from the point of support in water, i.e., the body seems to remain in a more unstable situation. In this sense, one might suppose that buoyancy and drag forces act to stabilize the body. The results of this work are encouraging in the sense that BCOM analysis might help in clarifying aspects of motor control in water. However, since dynamic stability relies on multiple somatosensory, visual and vestibular inputs, it is important to investigate further the effect of water environment on these inputs in order to identify strategies of CNS for underwater motor control.

Gait Parameters During Obstacle Avoidance in Parkinson's Disease Patients

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The signs/symptoms of Parkinson's disease (PD) influence patients to present difficulties in performing sequential tasks. However, the patient's behavior during walking and stepping over an obstacle is less known. This task requires the subject to perform different trajectories for the leading and the trailing limbs which must be planned in advance. The aim of this study was to verify the effects of obstacle height on the gait parameters of the adaptive step over the obstacle. Twelve patients with

idiopathic PD (6 men and 6 women; age 67.92 + 8.47 years old; 33.25 + 19.18 points for UPDRS; severity stages from 1 to 3 by Hoehn and Yahr Scale) were selected for participation in the study. Passive markers were attached at the fifth metatarsal, calcaneus, and lateral malleolus of right limb (leading limb) and first metatarsal, calcaneus, and medial malleolus of the left limb (trailing limb). Participants were invited to walk and step over each one of two personalized obstacles (mid shank and ankle height) that were placed on the middle of a 10 m long and 1.4 m wide pathway, during 5 trials per condition. Spatial parameters of gait while stepping over the obstacle were collected by two digital camcorders at 60 Hz on the right sagittal plane. The photogrammetric procedure was performed by means of Dvideow version 6.3 software. MatLab version 6.5 software was used for filtering and calculating the following dependent variables: leading and trailing foot placement prior to the obstacle (LFPL and TFPL), leading and trailing toe clearance (LTCL and TTCL), and leading foot placement after the obstacle (LFPA). Repeated measures ANOVA (obstacle height as a factor) by trial and for each dependent variable was used to verify the influence of obstacle height on gait parameters during obstacle negotiation. The results revealed that obstacle height affected the following adaptive gait parameters: LFPL [$F(1,59) = 9.912$; $p < 0.003$], the safety margin over the obstacle for leading and trailing limbs [$F(1,59 = 19.141$; $p < 0.001$; $F(1,59) = 9.769$; $p < 0.003$]; respectively), and LFPA [$F(1,59) = 4.029$; $p < 0{,}049$]. In the presence of the higher obstacle, patients decreased the safety margin for both limbs, placed the leading limb further to the obstacle before crossing and landed the leading foot closer to the obstacle after crossing it. These results revealed that: a) obstacle height modulated the gait parameters of the adaptive step over the obstacle; and b) the leading limb is more affected by the obstacle height than the trailing limb. (Acknowledgements: FAPESP, CNPq, CAPES, FUNDUNESP, FNS-MS.)

Obstacle Avoidance Behavior of Cerebral Palsy Children: Preliminary Data

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Children with diplegic spastic cerebral palsy must be able to overcome the opposite forces of spasticity in order to achieve successful locomotion in the environment. Since the environment is not always even, how do these children avoid obstacles in their path? The aim of this study was to verify the effects of obstacle height on the gait features of children with diplegic spastic cerebral palsy. Four boys with diplegic spastic cerebral palsy (10.45 ± 3.1 years of age; 125.5 ± 14.37 cm in height; and 27.37 ± 9.88 kg of body mass) were invited to participate. According to the Ashworth scale, two boys had more involvement of the right lower limb, while with the other two, the left lower limb was more affected. Reflective markers were attached bilaterally on the following body points: lateral and medial malleolus, and first and fifth metatarsal joints. The participants walked on 8 m-long pathways and stepped over a foam obstacle. Obstacle heights were personalized for each participant according to their body scale: high obstacle (half of knee height); middle obstacle (1/4 of knee height) and low obstacle (ankle height). Their locomotor behavior was recorded using two digital camcorders on the right sagittal plane in three trials per condition. The photogrammetric procedure was performed by means of Dvideow

version 6.3 software. MatLab version 6.5 software was used for filtering and calculating the following dependent variables: leading and trailing foot placement prior to the obstacle (LFPP and TFPP), leading and trailing toe clearance (LTCL and TTCL), and leading and trailing foot placement after the obstacle (LFPA and TFPA). One-way analysis of variance (ANOVA) by trial was applied to observe obstacle height main effect. Tukey's test with a 0.05 probability level was used for post hoc comparisons. The ANOVA revealed obstacle height main effect only for LTCL [$F(2,48) = 6.879$; $p < 0.002$], and the Tukey's test showed differences between the high and medium obstacles ($p < 0.002$) and high and low obstacles ($p < 0.017$). Diplegic spastic cerebral palsy children raised the leading limb more during the high obstacle avoidance, which is particularly instable. Perception of the obstacle height modulated the effectors system in a similar way during the approach and landing phases, but not during the crossing phase, and only for the leading limb. This locomotor behavior indicates that children with diplegic spastic cerebral palsy planned the locomotor adaptive behavior, modulating the safety margin. (Acknowledgements: FAPESP, FINEP, CNPq, FNS/MS.)

Body Weight Support System: Treadmill Versus Overground Walking

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Gait training with body weight support (BWS) system has become an extensively used approach in patients with neurological impairments. However, this approach has been employed only for treadmill gait, and there is no information available concerning the implications for the use of BWS system on overground gait. Therefore, the goal of the present study was to analyze the gait characteristics of healthy young adults walking overground and on a treadmill with and without the BWS system. Eight young and healthy adults volunteered for the study, and they walked at self-selected speed in four different conditions: (1) overground with 30% of BWS, (2) overground with no BWS, (3) on a treadmill with no BWS, and (4) on a treadmill with 30% of BWS. In the first condition, the mean walking speed was set and the participants had to walk at the same speed in the remaining conditions. IRED emitters were placed over the main anatomical landmarks and data were registered using the OPTOTRAK system. From these data, stride characteristics and joint and segmental angles were calculated in the four different walking conditions. Stride length was longer and speed was higher on overground than on treadmill walking and the temporal organization was different among the different walking conditions. In terms of joint angles, knee range of motion (ROM) was larger and hip ROM was smaller when the participants walked on the treadmill without BWS than when they walked overground and with the BWS. No differences were found for the ankle joint. In terms of segmental angles, foot and shank ROMs were larger when participants walked overground than when they walked on the treadmill, trunk ROM was larger when participants walked with the BWS than when they walked without the BWS, and no differences were found for the thigh. From these results, it might be inferred that either the treadmill or the BWS system can modify the way the participants walked. When comparison between the conditions with the

BWS system and the conditions with no BWS system was made, it was observed that their thigh and trunk were straighter with the BWS system than without it, the duration of first and second double-limb stances were lower, the single-limb stance and balance were higher with the BWS system than without it. In conclusion, the BWS system modifies some of the walking characteristics in healthy young adults and these modifications might benefit walking training in patients with neurological impairments.

Is the Von Holst Problem Solved During Slope Walking in Quadrupeds?

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The physical demands of walking up a slope are different from those during down slope walking and therefore require different patterns of muscular activity. For example, the feline anterior biceps femoralis muscle is used for propulsion during walking upslope but remains silent in stance during down slope walking when the gravitational force supplies a hip extensor moment. Recent data from our laboratory (Gottschall JS, Nichols TR, Soc Neurosci Abstr 2006) utilizing the premammillary cat preparation suggest that the alterations in muscular activation patterns for changed conditions of slope may result from the calculation of body orientation in space from vestibular and neck afferent information. If an animal were to maintain its head in a neutral position with respect to gravity, neck afferent information would then code body orientation. If the animal were then to move its head voluntarily during the locomotion, both sensory systems would be affected in parallel and no change in activation from the currently appropriate pattern would result (von Holst E, Mittelstaedt, 1950, the reafference principle). We suggest, therefore, that the interaction of vestibular and neck afferent information regulates not only the postural state of the limbs (Roberts TDM, 1967, Neurophysiology of Postural Mechanisms) but the central pattern generator as well. However, during treadmill stepping in the premammillary state, information from the neck afferents are apparently processed in advance of vestibular feedback, since changes in head pitch do result in transitory changes in muscular activation patterns. These transitory changes conform to those expected for the usual neck position for the corresponding slope direction. When the head of a stepping animal is rotated up about the pitch axis by the experimenter, corresponding to down slope walking, no activation is observed in the anterior biceps femoralis muscle during stance in contrast to the marked activation of this muscle during level or upslope walking. The time course of the transient changes varies somewhat among preparations from one to several step cycles, and most commonly occurs during 2-4 step cycles. One interpretation is that this delay in the vestibular response is due to the fact that the head movements were imposed by the experimenter. In voluntary head movements, associated motor commands to the brainstem could result in more complete cancellation of the two signals. Alternatively, the advanced neck afferent signal could provide an initial priming of the change in motor pattern. (Supported by NS20855 and NIH NS054542.)

Gaze Behavior During Locomotion Over Obstacles in Children and Adults

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Vision provides feedforward information to guide locomotion. Previous research has shown that travel fixations are located 2 steps ahead of a person's location, and gaze fixations occur on relevant aspects of the task, such as on obstacles or on an end goal. Considering that the visual system is still in development during childhood, gaze behavior could be different in children. Therefore, the aim of this study is to analyze gaze behavior during locomotion over obstacles in children and young adults. Young adults and 10-year-old children were asked to walk across a 6-m walkway to reach a goal (a basket with colored balls). In each trial, participants had to avoid a wooden obstacle placed in the middle of the walkway. The obstacle varied in height: 2 cm, and 10% and 20% of participants' height. Participants performed 3 trials at each obstacle's height in random order. Gaze behavior was recorded using an eye-tracking system (ASL, Bedford, MA). Fixations were computed every time that gaze stayed in the same position for 100 ms or more. For each fixation, the duration and location (obstacle, goal, walkway, or elsewhere) was determined. Both adults and children fixated on relevant locations. Total gaze fixation time and fixation location were not influenced by the obstacle's height. The average duration for single fixations was similar for children and adults (0.12 ± 0.06 s and 0.12 ± 0.07 s, respectively). In adults, the total gaze fixation time on the goal was longest (1.64 ± 0.55 s) followed by gaze fixation on the walkway (0.72 ± 0.43 s) and the obstacle (0.34 ± 0.36 s), respectively. However, children spent more time fixating on the obstacle (1.00 ± 0.66 s) than on the goal (0.69 ± 0.22 s), or on the walkway (0.36 ± 0.19 s). The number of fixations followed the same trend as the total gaze fixation duration: adults showed more fixations on the goal (10.02 ± 3.38 fixations), while the number of fixations on the obstacle was higher in children (6.15 ± 3.12 fixations). Results show that children rely more on visual information regarding the obstacle, which suggests attentional demands to the obstacle in order to avoid it. Furthermore, 10-year-old children show mature gaze behavior in terms of single gaze fixation duration and highly task-relevant gaze fixation. (Support: NSERC, Canada; CAPES, Brazil; Graduate Studies Office, University of Waterloo, Canada.)

Variability of Stride Trajectory in Different Intervals During Prolonged Run

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During locomotion, the segment trajectory measurement presents relevant information about movement performance. Considering this kind of analysis as the description of each point of the body in space, optimization of motor tasks depends on the trajectory regularity. Comparing movements accomplished by the same person under the same conditions, different patterns of performance can be noted which may allow the investigation of some motor control dysfunctions related to

abnormal rhythmic structures. The movement patterns of running correspond to complex actions, which require much coordination to reach the regularity aimed in order to avoid unnecessary energy expenditure and fatigue that could lead to decrements in performance or even to injuries. The aim of this study was to analyze the stride trajectory variability in different running intervals. Nine experienced male triathletes performed a prolonged run, which duration was determined by a cycling and running time-trial. The speed of the test was normalized using the average velocity during the triathlon running. The kinematics data of stride trajectory, considering both vertical and horizontal axis, were measured by means of recordings from a reflexive mark localized on calcaneus. Six different intervals were considered for analysis: 5th, 20th, 40th, 60th, 80th and 100th minute. The Peak Motus system (Peak Performance, Inc., USA) was used for acquisition and analysis of bidimensional data from the sagittal plane. The trajectory variability was determined considering mean values and coefficient of variation (CV) of ten strides per interval. The duration of prolonged run was 1 h 42 min ± 5 min with average speed 13.91 ± 1.18 km/h. The greater CVs were found at 5th minute of test, 7% and 14% for horizontal and vertical axes respectively. There was a decrease for CV on both axes from 20th minute with few alterations until the end of the test. The variability on vertical axis was always larger than on the horizontal one. Thus, the initial greater stride trajectory variability (for both axes) is possibly related to adaptations needed to these specific movement patterns, also demonstrated by CV values stabilization from the second interval to the end of test. Since the present data show greater CV for vertical axis, prolonged runs may be more associated with different hip and knee angles in order to maintain performance. The triathletes presented movement regularity which may reflect an optimized running pattern, probably related to their high motor skill level.

Kinematic Variability During Walking At Different Speeds and Machines

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The objective of this study was to compare the angular kinematics pattern during walking on different exercise machines. The subjects were five healthy women (62.8 ± 5.0 kg weight, 1.70 ± 0.08 m height, 30.2 ± 6.9 years old). The right lower limb positions were recorded from six reflective marks with a digital camera. The marks were placed on the anterior superior iliac spine, greater trochanter of the femur, lateral epicondyle of the femur, lateral malleolus of the fibula, 5th metatarsal head and calcaneous. Subjects walked on a treadmill and elipticon aerobic at two different walking frequencies, determined by a metronome (slow: 80, and fast: 120 bpm). The video analysis was run with Ariel Performance Analysis System. All signal process was run with Matlab codes. The hip, knee, and ankle angular positions and velocities were analyzed. When the subjects were walking with the feet always fixed (elipticon aerobics), the knee variability (variability coefficient) was the lowest; as when they were walking at the treadmill, the ankle variability was the lowest. Comparing the ensemble average of hip, knee, and ankle angular

positions during a complete gait cycle, we found that the hip angular time pattern was the most affected by different cadencies. As a conclusion, we suggest that the lowest variability reflects the controlled joint during walking. It means that during walking on a treadmill, the main concern is about feet position, so the ankle variability decreases, while when walking on the elipticon, and the knee position is the most important kinematics variable.

Physical Activity and Sports

Status of the Bilateral Deficit (BLD) in Youth Soccer Players Who Are Being Directed Towards High Performance

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This research determined the status of the bilateral deficit (BLD) in terms of variability among individuals, categories and playing positions in youth soccer players who are being directed towards high performance. Two hundred twenty-one soccer players distributed into 11 categories from youth division of the Asociación Deportivo Cali in Colombia, participated in this investigation executing 9 Abalakov jumps (Acero-Ibargüen, 2002 Protocol) on a contact platform (New Test) using three modalities: right leg, left leg and bilateral. Results showed that 38.91% of players had a good percent BLD, 8.14% were acceptable, 24.89% were regular and 28.05% were deficient. The pre-infant and gorrion categories acquired the best BLD results. The center back (% BLD x = -19.96) and forward players (% BLD x = -19.68) were the best performers with good level of acceptability. As a process, the Acero-Ibargüen, 2002 Protocol, is easily applied, quick and objective to evaluate the percent BLD and allows projecting the fact that this neuromuscular phenomenon will become as an indicator of the condition of recruitment of fast motor units. A new body kinetic concept concerning this type of youth player will emerge.

Types of Stride Pattern and Time Distribution in Elite 400 m Hurdlers

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Introduction: The results in 400-m hurdle run (400-mH) depend on both motor and coordinative aspects. Final result in 400-m run is a function the partial times. The basic problem in effective race is so called "stride pattern" that is wrong definite as a "stride rhythm." Stride pattern is a number of strides between 10 hurdles. *Purpose*: The aim of this study was to find an optimal race model for hurdlers with specific stride pattern. *Material*: In our investigations we drew on 400H races from the most important athletic meetings (Olympic Games, World and Europe Championships) from 1968 to 2004. The data was compiled by many authors (e.g., Letzelter et al. 1975, Susanka et al. 1988, Bruggemann & Glad 1990, Ditroilo & Marini 2001) and finally 101 athletes were chosen (age: 25.9 ± 3.5 years, height: 185.2 ± 4.8 cm, weight: 76.6 ± 5.5 kg). *Methods*: In this study we collected 101

individual runs separated into four types of transition: "single alternate" – from 13 to 14 strides (group A; n = 27), "paired alternate" – 13-14-15 strides (group B; n = 22), "double step down" – from 13 to 15 strides (group C; n = 25) and second form of "single alternate" – inter-hurdle strides from 14 to 15 (group D; n = 27). The data consisted of somatic parameters (3), motor and technical achievements (3), split times (= inter-hurdles times and times in three parts of distance - 1-4H, 4-7H and 7-10H) number of strides between every inter-hurdle spacing and between three parts of the run. One-way analysis of variance (ANOVA) was performed to examine the significance of group differences. *Results*: The physical parameters and final results in 400H were not significantly different between groups A, B and C. Somatic build and level of sport achievement were higher in above groups in comparison to the group D. The distribution of effort was similar in groups B and C. Significant differences in partial time races were placed in groups A-C (the most important was first part of runs) and A-B (decisive was run over 7th hurdle). The results of this study showed that the choice of stride pattern in 400H determined distribution of time race. The chance of stride pattern in group C (13-15 strides) was placed after 5th hurdle, in group B (13-14 strides) after 7-8 hurdles. The most important for efficiency of hurdle race was time from 5th to 7th hurdles (especially in group C) and from 7th to 9th hurdles (group B). In groups A and D we observed proportionally similar race distribution, despite pace of race.

Possibilities of Using Vienna Test System to Estimate Rhythm Abilities in High Level 110-m hurdlers

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Introduction. Rhythm is an important element of achievements in 110-m hurdle run. So far the study of rhythmic abilities in group of high level hurdle-runners were rather intuitive than empirical. The aim of this investigation was to find accurate forms of laboratory tests to assess rhythm abilities in high level hurdles. *Material*. In this study participated 13 best Polish 110-m hurdlers (personal best: 13.87 ± 0.79 s, age: 23.1 ± 2.9 years, height: 185.3 ± 4.2 cm, weight: 76.9 ± 5.9 kg) and, as a control group, untrained students of physical education from Katowice (age: 21.6 ± 1.7 years, height: 178.3 ± 10.1 cm, weight: 77.9 ± 5.3 kg). *Methods*. To determine the level of rhythmic abilities we used the Vienna Test System (Austria) with addition system TAP (version 4.00) produce a sequence of two sorts of sound (S - "slow" – 72 beats/min and F - "fast"- 144 beats/min). The tests consisted of three phases: preparation, guided and unguided; in this study we used results only in the last one. To predict rhythmic abilities we created 10 basic tests. Between them were 6 general trials (right leg – R, left leg-L and both lower limbs-B; every test in slow and fast version) and 4 specific, simulate hurdle race (1 hurdle clearance + 3 inter-hurdle steps) – 3R1L and 3L1R, both in variants S and F as well. From the above tests we separated 4 similar group variables contained four tests:

first: one leg movement (in versions LS, RS, LF and RF); second: two leg variants (BS,BF; in variants started from L and R leg); third – specific hurdle rhythm with using left leg as a lead leg (3R1L and 1L3R, both in versions S and F); and fourth – specific hurdle rhythm with right lower limb as a lead leg (3L1R and 1L3R). Additionally we used 2 types of assess rhythmic abilities: "reproduce error" (= average time differences with rhythm pattern) and "defused error" (= average time differences between own, individual rhythm). Two-way analysis of variance (sport level × group of tests) was used to examine significance differences. *Results*. ANOVA revealed a significant sport level interaction ($F = 4.64$, $p \leq 0.035$) only in one-leg complex of tests (first variant) in range of "reproduce error." There were no differences in group of hurdlers and control in specific block tests (third and fourth versions). Assessment of "defused error" showed that there were significant differences between all groups of tests ($p \leq 0.001$). The study showed that using laboratory tests to estimate rhythmic abilities in professional hurdles is difficult and required more experiences and scientific studies.

How Realistically Do Parents Evaluate Their Preschool Children's Health Behaviour and Physical Activity?

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Sedentary behavior and obesity are increasing health challenges of children in developed countries. The home and preschools play a central role in promoting health education and physical activity habits. The realistic awareness of parents and teachers about children's health behavior is essential in order to activate children to be physically active and adopt healthy behavior models. Previous studies suggest that parents evaluate their children's physical activity unrealistically, especially in the case of girls. This may lead to underestimation of the need for promotion of physical activity in the family. The aim of the study was to analyze differences between parents' and teachers' views about children's health behavior and physical activity as a part of the Comenius Program for early childhood physical education curriculum development. The participants were parents and preschool teachers of 358 children, 4-5 years of age in Finland, Greece, Cyprus, and the UK. The 14-item questionnaire evaluating children's health and physical activity was administered to the parents at the start of the three-month physical education intervention program. Preschool teachers also evaluated the children using the same protocol. There were several statistically significant differences in the evaluations. In twelve health and motor skill related items out of fourteen the parents evaluated their children more positively than the preschool teachers. T-tests revealed statistical differences ($p = 0.000$) in the case of both girls and boys in the evaluations of manipulative skills, locomotor skills, balancing skills, discriminating healthy from unhealthy food, and enjoyment of participation in physical activities. The parents evaluated boys more positively than the teachers in 12 items, whereas the same was true for girls in only nine items. The results show that there is a need in preschools to inform the parents about their children's development challenges in health behavior and physical activity.

Effects of the Association of Resistive Exercise and Stretching on the Rat Muscle Fiber Morphology

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Objective: Evaluate the effect of the association of progressive loading exercise and stretching in the rat soleus muscle morphology. *Material and Methods*: Twenty-three male Wistar rats (380 ± 50 g) were divided into 4 groups: Control Group (CG) (n = 3) intact control group; Stretch Group (SG) (n = 6) the left ankle was held in full dorsal flexion by a piece of tape, for 40 min, to stretch the left soleus muscle, twice a week for 8 weeks; Progressive Loading Exercise Group (PLEG) (n = 6) the animals were trained in a progressive loading exercise carried out by fixing an additional load on the animal's body. The protocol consisted by 4 bouts of 10 jumps, resting 60 s between each bout, in a container filled with warm water, 3 times/week, for 8 weeks; Progressive Loading Exercise and Stretching group (PLESG) (n = 6) the animals were submitted to both protocols PLE and Stretching. After 8 weeks all the animals were weighed and euthanized to soleus muscle excision. The following variables were evaluated: body and muscle weights, muscle length, serial sarcomere number, sarcomere length and cross-sectional area (CSA). An increase in the final body weight in the group PLESG was observed when compared to the initial ones (370 ± 16 g vs 322 ± 24 g, p = 0.007, paired t test). The muscle weight of the PLEG was superior (0.24 ± 0.03 g) than CG (0.18 ± 0.02 g, p = 0.003, ANOVA), SG (0.19 ± 0.01 g, p = 0.01, ANOVA) and PLESG (0.16 ± 0.01 g, p = 0.0003, ANOVA). The left soleus length in the PLESG was inferior (16.2 ± 1.47 mm) when compared to CG (19 ± 1.41 mm, p = 0.04, ANOVA), SG (19.9 ± 1.2 mm, p = 0.005, ANOVA) and PLEG (21.8 ± 2.4 mm, p = 0.0003, ANOVA). The group submitted to PLE showed an increase in the soleus length in comparison to the CG (21.8 ± 2.4 mm vs 19 ± 1.41 mm, p = 0.05, ANOVA). The PLESG presented a decrease in the serial sarcomere number when compared to SG (p = 0.002, ANOVA) and PLEG (p = 0.001, ANOVA). An increase was observed in the CSA of the SG (1896 ± 342 μm^2) when compared to the CG (1869 ± 163μm^2, p = 0.04, ANOVA). The sarcomere length did not change. *Conclusions*: The association of loading exercise and stretching did not prevent the gain of body weight. However, this combination decreased the muscle length and the serial sarcomere number that suggest lesion induced by the daily overloaded. The stretching protocol applied isolated was efficient to induce muscle hypertrophy. (Financial support: Tuiuti University of Paraná and Evangélica Faculty of Paraná.)

Coordination of the Internally and Externally Timed Soccer Kick

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Several studies have investigated the coordination of the soccer kick (e.g., Anderson & Sidaway, 1994; Shang & Westerhoff, 2005). However, none of these studies have focused on kicking a moving ball, which is more common in soccer than kicking a stationary ball and requires the timing of the kick to be controlled in relation to the movement of the ball. This is likely to be an aspect of skill that is more developed in more experienced soccer players. Eight right-footed males with competitive football experience and ten without such experience were asked to kick a soccer ball quickly and accurately with the right foot using a two step approach run towards a target 3 m in front, 1.4 m above the floor. Each participant performed 20 kicks (10 stationary balls, 10 balls projected from the participant's right at 3 m/s) in randomized order. 3-D movements were recorded at 200 Hz with a CODA motion system (Charnwood Dynamics). A digital video camera recorded the landing position of the ball. Experienced participants kicked more accurately than less experienced participants [$F(1,16) = 5.45$, $p < .001$], especially in the moving ball condition ($p = 0.056$). No difference was found for the foot velocity at ball contact. Both groups showed a proximal distal initiation sequence in the kicking leg in both conditions. Visual inspection revealed the hip-knee coordination to be less coupled after initiation in experienced participants. This group displayed a shorter time between initiation of the forward swing of the kick (maximum hip angle) and ball contact (0.22 s) than the less experienced group [0.26 s; $F(1,16) = 5.12$, $p < .05$], due to a shorter duration of knee flexion [0.18 versus 0.21 s; $F(1,16) = 4.76$, $p < .05$]. Joint ranges of motion were not different. Fast knee flexion may have been a strategy to increase accuracy (by exploiting passive forces to reduce noise) rather than velocity, but this requires further study. No interactions were found between experience level and condition. In the stationary compared to the moving ball condition, a shorter knee flexion phase [0.18 versus 0.20 s; $F(1,16) = 6.14$, $p < .05$] and a larger knee range of motion [69° versus 63°; $F(1,16) = 11.03$, $p < .01$] was found. Coefficients of variation were particularly low for knee range of movement and foot velocity, indicating that these are tightly controlled in the coordination of the kick.

Coordinating Undulatory Underwater Swimming: A Comparison Of Skilled Versus Unskilled Swimmers

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Comparisons of coordination patterns of skilled and unskilled individuals have been undertaken to demonstrate the fundamental differences in performance for a variety of different tasks. Undulatory underwater swimming (UUS) following the starts and turns of a swimming race is recognized as an important component of overall performance. Phase relationships between the vertical oscillations of the joint centers along the length of the body have been used to evaluate the proficiency of UUS coordination and performance, as wavelike oscillations along the body can generate a propulsive waveform. The aim of this study was to compare the phase relationships of the joint centre vertical oscillations between skilled and unskilled swimmers to identify fundamental differences in coordination and performance. Each of nine skilled and nine unskilled swimmers performed three trials using UUS at maximum speed. An underwater JVC camera with its axis perpendicular to

the swimmers plane of motion recorded three complete body cycles at fifty-fields per-second. Joint centers were digitized and raw data transformed using a subject-derived scale factor, followed by Fourier truncation at 7 Hz. The mean phase angles (θ) of the vertical oscillations were quantified using Fourier analysis, to determine if propulsive waveforms were present and how effective they were. Displacement data were used to calculate joint angles at the shoulder, hip, knee and ankle. Joint angle data was normalized to a kick cycle and displayed in angle-angle plots to assess variability of swimmers coordination. Kick frequency, amplitude and average swimming velocity were also calculated. Unsurprisingly, skilled swimmers' average velocity was faster (1.34 ms^{-1}) than unskilled (0.79 ms^{-1}). No significant difference ($p > 0.05$) in kick frequency or mean θ for any joint center vertical oscillations was found. However, differences in the variability (SD) in kick frequency and mean θ for all joint oscillations were evident, with unskilled swimmers demonstrating greater variability. Mean θ data confirmed propulsive waveforms were present in both groups. However, skilled swimmers data demonstrated a more effective "whip-like" action, with larger changes in mean θ along the caudal aspect of the body. Qualitative assessments of angle-angle plots revealed unskilled coordination to be more variable than skilled. The amplitude of oscillations at the wrist and shoulder were smaller in the skilled than unskilled swimmers, consistent with the goal of minimizing resistive drag when swimming. There were clear differences in performance and coordination. However, further research is required to investigate the process and evolution of coordination from unskilled to skilled performance.

Changes in Flexion Relaxation Response Induced by Lumbar Muscle Fatigue

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The flexion-relaxation phenomenon (FRP) is defined by the reduction or silence of the myoelectric activity of lumbar erector spinae observed during full trunk flexion (Colloca et al., 2005). The mechanism underlying FRP has been proposed to represent a shift in load sharing and spinal stabilization from active structures to the passive ligamentous and articular structure (Geisser et al., 2004). Olson and Solomonow (2004) studied the effect of repeated cyclic lumbar flexion and concluded that modification in the EMG patterns along cycles may be caused by increased muscular fatigue. Despite these preliminary results, the effects of muscular fatigue on FRP parameters have not been studied thoroughly. Consequently, the objective of the present study was to identify the effect of erector spinae and multifidus muscle fatigue on myoelectric silence onset and cessation in healthy individuals during a flexion-extension task. Twenty healthy subjects were recruited from the Chiropractic Clinic of the Université du Québec à Trois-Rivières and participated in this study. Subjects performed blocks of three complete trunk flexions under two experimental conditions: 1) no fatigue and 2) fatigue. Fatigue was induced using the Sorenson protocol and EMG power spectral analysis (median/time slope) was used to confirm that muscular fatigue was induced correctly. Trunk and pelvis angles and surface EMG of the erector spinae and superficial multifidus were

recorded during a flexion-extension task. The flexion angle corresponding to the onset and cessation of the myoelectric silence were then compared across the different experimental conditions (repeated ANOVA). The angle that corresponded to the onset of myoelectric silence was significantly reduced after the fatigue task for both erector spinae level (84.9 ± 4.3 vs 77.3 ± 3.4; [$F(1,16) = 17.2$; $p < 0.01$]) and multifidus level (74.7 ± 4.8 vs 70.4 ± 3.9; [$F(1,15) = 11.7$; $p < 0.01$]). Additionally, the angle corresponding to the cessation of the myoelectric silence significantly decreased after the fatigue task both erector spinae level (93.0 ± 3.9 vs 84.4 ± 2.8; [$F(1,16) = 11.4$; $p < 0.01$]) and multifidus level (92.0 ± 4.1 vs 84.9 ± 3.4; [$F(1,16) = 15.1$; $p < 0.01$]). The results of the present study indicate that the presence of muscular fatigue of the multifidus and erector spinae muscles modifies the onset and cessation angles of the FRP. Superficial back muscles fatigue seems to induce a shift in load sharing towards passive stabilizing structures and potentially deep lumbar muscles. Muscular fatigue of the lumbar erector spinae and multifidus may temporarily reduce spinal stability and subsequently put at risk previously injured structures. Interaction between chronic pain and muscular fatigue and their effect on FRP should be studied.

Effects of a Physical Activity Program on the Daily Life Activities of Elderly With Parkinson's Disease

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Morpho-functional decays occur with the aging process which affects the performance of motor skills, such as the reduction in range of motion. The association of these decays and the symptoms of Parkinson's disease modify the relationship between the individual and the environment. Parkinson's disease directly affects motor functions due to the decreased dopamine production by the dopaminergic neurons located on substance nigra pars compacta of the basal ganglia. Consequently, falls can occur due a loss of fluidity and efficacy in the performance of daily tasks such as shopping and going up and down stairs. Parkinson's disease patients improve their motor dysfunctions with medication. However, little is known about the effects of physical exercise on their motor skills. Thus, the aim of this study was to verify the effects of enrollment in a physical activity program on the functional mobility of Parkinson's disease patients. Eight patients averaging 65.87 ± 8.47 years of age participated in this study. A psychiatrist clinically evaluated and classified the patients among the stages 1 to 2 on the Hoehn & Yahr scale. Three trials of the Timed "Up and Go" (TUG) and Posturo-Locomotion-Manual (PLM) tests were performed in order to measure their functional mobility. The dependent variables for both tests were the duration and the number of steps to perform the task, prior to and after attending the program of generalized physical activities. This program ran for 6 months with 3 one-hour sessions per week. In order to verify the effects of the physical activities program, a *t*-test was used for temporal variables and the Wilcoxon test on the number of steps, all with 0.05 as a significance level. The *t*-test showed differences for both the TUG ($t23 = 7.323$; $p < 0.001$) and the PLM ($t23 = 2.956$; $p < 0.008$) tests. The patients performed both tests faster following participation in the program of generalized physical activities.

For the number of steps, the Wilcoxon test revealed differences only for TUG ($Z24 = -2.121$; $p < 0.035$). The patients reduced the number of steps performing the task probably due to the increased step length. The program of generalized physical activities was sufficient to improve functional mobility, and it is probably an important factor to minimize the risk of falls. We recommend the enrollment of Parkinson's disease patients in physical activity programs. (Acknowledgements: FINEP, FAPESP, FNS/MS.)

Electromyographyc Activity Patterns of a Paralympic Athlete with Sequelae of Polio During Arm Cranking

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The performance of elite athletes is strongly dependent on good motor control and muscular coordination, mainly when precision is required. Due to this, coaching paralympic athletes with neurological sequelae such as those of poliomyelitis is a challenging task, since training methodology must be fitted to each athlete. In this sense, it is important to evaluate relevant aspects of motor abilities of these athletes. This was done in the case of a female paralympic athlete, with sequelae of polio, integrating the athletics team of CEDE-PUCPR, specialist in throwing events. Despite good results in competitions, her throwing pattern is not regular. During her shoulder isokinetic evaluation, the torque curve showed anomalous behavior and by arm cranking she was not able to maintain a regular rhythm. It was conjectured that irregular muscular activation patterns are related to this behavior. In order to investigate it, the electromyographic activity of the biceps and triceps brachii was registered during arm cranking. Electromyography bipolar electrodes were positioned over the biceps and triceps brachial and the signal was collected with the equipment EMG 1600CA (EMG System) with a sampling rate of 1 kHz and filtering between 20 Hz and 500 Hz. The athlete was firmly attached to the chair of a mechanical ergometer M4100 (Cefise) and then asked to perform three series of 4 min each, with interval of 10 min between them. During each series, the cadence was progressively increased, from 40 RPM until 70 RPM, increasing 10 RPM per each minute. The electromyography activity has shown the presence of co-contractions in both arms, but they appeared more frequently on the left side (non-dominant). When left pushing and right pulling, the left biceps have shown amplitude 5 times higher than that of the right biceps. This behavior has changed over the series: during the first series, the activation of muscles of the left sides was higher if compared to their right counterparts; during the second series there was a more symmetric behavior. During the third series, besides the interlimb asymmetry, it was observed that the left biceps remained activated along all the series. The results of this preliminary analysis have shown that muscular activation patterns might be the reason for the irregular throwing behavior. However, a more detailed analysis of the electromyography signals is necessary to identify the mechanisms behind it and help design a training program to correct the activation patterns and improve throwing performance.

The Point of No Return in a Time-to-Contact Task

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The Pont of No Return (PNR) in the execution of any movement is the moment, before the movement occurs, beyond which the neuro-muscular process is ballistic. This means that beyond the PNR the movement will occur no matter what, and it is impossible to respond to any external signal that indicates that it would be appropriate to alter the movement or even to prevent it from happening. We investigated the behavior of volunteers in a Time-To-Contact task in which they had to incline a lever to the right or to the left at the exact instant that a moving object on the computer screen coincided with a stationary object the same size, lying on its trajectory. At different times before contact a third point, which until then was stationary, moved randomly to the right or to the left. If possible the volunteer should incline the lever to the side opposite to the motion of the third object. If the third object moved only a short time before contact, the lever would be inclined to the correct side only 50% of the time (random performance), but if it moved well ahead of contact, volunteers inclined the lever to the correct side 100% of the time (perfect performance). The PNR to decide the side to which the lever should be inclined in this TTC task (half way between random and perfect performance) was found to be around 250 ms prior to contact. By monitoring eye movements prior and through contact, attention shifts in the execution of the task could be gleaned. By altering the speed of the moving object, it was possible to determine that attention shifts preparatory to action occurred more frequently when the movement was a certain distance from the stationary object ($p = 0.028$) rather than a certain time prior to contact ($p = 0.38$). These findings may be related to the ''Quiet Eye'' (QE) phenomenon, very important in tasks such as golf putts or free throws in basketball, where the objects that define how motion should occur are stationary. But rather than being organized in temporal terms (duration is important in QE), in a TTC task, with moving objects, spatial organization seems to be more important.

Effects of Stretching on Muscle Fiber Morphology of Female Osteopenic Rats

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Objective: Evaluate the effects of stretching on the soleus muscle of female estrogen deficient rats. *Material and Methods*: Twenty-seven female Wistar rats were

used (weight 218 ± 22 g) randomly divided into 4 groups: CONT (n = 3)- intact control group; OH (n = 8)- female rats were ovariectomized and hysterectomized and waited 4 weeks to induce osteopenia; STRET (n = 8) – left ankle was held in full dorsal flexion to stretch the soleus muscle, 10 bouts of 1 min with 30 s of resting between each, 3 times a week; OHS (n = 8) - female rats were ovariectomized, hysterectomized and the left soleus muscle was stretched. After 3 weeks the rats were euthanasied to excise both soleus muscles. Evaluated were: body and muscle weights, muscle length; serial sarcomere number; sarcomere length; cross-sectional area (CSA) and percentage of connective tissue. *Results*: The body weight increased in all the groups (CONT 25 ± 4%, OH 27 ± 6%, STRET 5 ± 3% and OHS 30 ± 11%). However, the muscle weight of OHS decreased 8 ± 4%. In contrast, the CSA of OHS (1682 ± 292 μm^2) and OH (1568 ± 285 μm^2) presented an increase when compared to the CONT (1262 ± 154 μm^2, ANOVA). The CSA from the OHS was higher than OH (1682 ± 292 μm^2 vs 1568 ± 285 μm^2, p = 0.0001, ANOVA). It was also found in the OHS a reduction of 7 ± 9% in the sarcomere length (3.03 ± 0.24 μm vs 3.28 ± 0.4 μm, p = 0.05, paired student t test). The muscle length decreased in OH (6 ± 4%) and also the serial sarcomere number (4 ± 3%). While the serial sarcomere number of the STRET presented an increase (7432 ± 726 vs 6869 ± 960, p = 0.003, paired student t test) compared to the right soleus and also the CSA (1573 ± 206 μm^2 vs 1262 ± 154 μm^2, p = 0.00001, ANOVA) in comparison with CONT. The percentage of connective tissue did not change. *Conclusions*: The estrogen deficiency provoked a decrease in the serial sarcomere number confirming sarcopenia and also induced an increase in the muscle fiber area probably caused by alterations in the myofibrillar structure to adapt to the new condition. However, the stretching possibly induced a hypertrophic effect on estrogen deficient muscles. Moreover, stretching performed on intact rats stimulated the sarcomerogenesis and increased the muscle fiber area suggesting hypertrophy. (Financial support: Evangélica Faculty of Parana)

Effect of Physical Activities on Postural Control in Elderly Individuals

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Our ability to control balance changes through aging. Many studies have shown that physical activity has positive effects to train and rehabilitate balance in the elderly. This research aimed to compare the balance among a group of seniors who practice physical activities (GPA) with a group of seniors who do not practice physical activities (GNPA) by means of a stabilometry board in orthostatic position. The sample was comprised of two groups of seniors of GPA and seniors of GNPA, with GPA comprised of 11 patients of both sexes, with a medium age of 68 years old, capable to stay in orthostatic position and free from muscle-skeletal lesions and/or important respiratory, cardiac, and neurological lesions. The GNPA was comprised of 11 healthy participants of both sexes who do not practice physical activities, with a medium age of 76 years old, the inclusion criteria for that group was the same as that for GPA. *Results*: The variable speed of sway was significantly different between groups (p = 0.02), with the GNPA group presenting the larger

speed of sway. The variable radial displacement was not significantly different between groups ($p = 0.52$), however a tendency of larger values was observed for the GNPA group. We think these results can be useful to define preventive strategies and in the formulation and prescription of programs of physical training for seniors who do not practice physical activities.

Dynamic Electromyographic Analysis of the Role of Lateral and Long Heads of the Triceps Brachialis During Elbow Extension at Pulley Machine

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This work aims at quantifying the synergism between long (TLo) and lateral (TLa) heads of triceps during a series of elbow extension (EE) by surface electromyography (SEMG). Twenty healthy males (ages between 18 and 24 years) accomplished concentric and eccentric muscular contraction in the EE exercise at a pulley machine. Movements with EEs between 90 until 180 degrees were repeated until fatigue at a cadence of one cycle at each 3 s. Electromyographic signals were collected by active Ag electrode pairs fixed on the TLa and TLo, at 50% of the distance between the acromion and the olecranon. The subjects were submitted to a one repetition maximum test; the exercises were performed after 5 min resting with 80% of the maximum weight. SEMG was amplified (gain 1000) and digitized at 2 kHz through an analog-to-digital converter with 16 bits resolution and dynamic range ±5 V. Movement artifact and high frequency noise were removed by two Butterworth digital filters, 8th order low-pass with cutoff frequency 400 Hz and 2nd order high-pass with cutoff frequency 10 Hz. For attenuating mains noise, six 2nd order stop-band Butterworth filters were applied centered on 60 Hz harmonics until 360 Hz, with 2 Hz bandwidth. The signals were thus decimated to 1 kHz and analyzed by spectrograms using short time Fourier transform with 1.5 s segments and superposition of 50%. For each data segment the median frequency and the total power was calculated. The spectrograms allowed observing an oscillating pattern of activity, mainly in TLa, which presented periods of relative resting at the end of the eccentric phase. This pattern was confirmed by the standard deviation of total power along the exercise series, with was significantly higher in TLa than in TLo: 11.459 ± 7.368 and 6.937 ± 5.050 105 (μV)2 respectively; $p = 0.0294$. The median frequency decreased in both TLa and TLo during the fatigue development, with TLo showing faster slope than TLa (1.3344 ± 0.5098 and 0.9026 ± 0.3176 Hz/s respectively; $p = 0.0027$), giving a clear indication that this muscle portion is the first to reach fatigue. This finding suggests TLo as responsible for braking and accelerating the forearm in the eccentric to concentric transition. As a conclusion, the dynamic SEMG analysis of the triceps brachialis during EE allowed us to determine the differences of loads in muscle heads, being a useful tool for the prescription of located exercises.

The Influence of Stress in Motor Control

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This work has as its objective evaluating the effect of stress in the performance of volunteers in the execution of a "Time to Contact" (TTC) task that simulates on a computer screen some aspects of the penalty kick. The volunteers participated in the experiment in two conditions: alone in the laboratory and in a classroom, with spectators. The task was displayed on a computer screen where three circles symbolized a goalkeeper (under a goal mouth), a ball, and a kicker. Each trial started with the "kicker" moving upwards with constant speed in the direction of the "ball." Participants were instructed to incline the lever at the exact moment of kicker-ball coincidence (which lasted 17 ms due to refresh rate of the screen, and started 1344 ms after the beginning of the trial). Participants performed 40 trials in which the goalkeeper randomly remained in the middle of the goal mouth (20%), moved to right (40%) or to the left (40%) at different times before kicker-ball coincidence. If possible, participants should tilt the lever to the opposite side of the goalkeeper movement. The sideways motion of the "goalkeeper" occurred randomly at one of 9 possible moments: 51, 102, 153, 204, 255, 306, 357, 408, or 450 ms before kicker-ball coincidence. In the laboratory (control condition), the percentage of responses with correct laterality increased from about 50% to 100% when the goalkeeper moved about 250 ms before the contact. In the experimental condition, on the other hand, with volunteers under the stress induced by the presence of participating spectators, the transition occurred when the goalkeeper moved earlier (290 ms before contact), but, interestingly, the performance of the volunteers when the goalkeeper moved very early saturated not near 100% but around only 80%. It seems stress exerts a negative influence in deciding which side to move, increasing the time necessary to respond to goalkeeper motion, and introducing errors even when the time available to make the decision is very long. We speculate that the situation of stress is associated with or induces imagining committing an error, which means implementing the wrong motor program, which then leads to mistaken movement execution.

Movement Disorders

Bimanual Fingertip Force Control in Hemiplegic Cerebral Palsy

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In the present study, unimanual and bimanual fingertip force control during object grasping in children with hemiplegic cerebral palsy (n = 7, age 4.5 - 13.6 years) was studied. Participants lifted, transported and released objects with one hand or both hands together. The effect of bimanual lifting on fingertip force control for each hand was determined. Specifically, it was examined whether any benefit

exists for the more-affected hand when it performed the task concurrently with the less-affected hand. In the bimanual conditions, the weight of the instrumented objects was equal or unequal. The duration of the different temporal phases of grip generation were analyzed, together with the force-related parameters. Our findings of the force variables showed a small benefit for the affected hand when it lifted the object simultaneously with the less-affected hand. In contrast, the durations of the load phase (isometric force increase), transport phase and the total movement time of the affected hand were adversely affected. That is, during bimanual control as compared to unimanual control the durations of these phases were prolonged. These findings suggest that therapeutic intervention may use bimanual tasks as they have the potential to facilitate force control of the affected hand. However, this may be at the cost of slower movement performance.

Motor Imagery in Right Hemiparesis is Dependent on Posture Congruency

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In a recent study it was shown that the ability to use motor imagery was compromised in right congenital hemiparesis, viz. left hemisphere damage (Mutsaarts et al., 2006). However, posture of the displayed stimuli and the actual posture of the hand making the response were incongruent in that study. Ample evidence exists that such an incongruence negatively influences laterality judgments in a motor imagery task, which may have affected the findings in the Mutsaarts et al. (2006) study. In the present study, three participant groups (control participants, participants with left hemiparesis, and participants with right hemiparesis [all $n = 11$]) were engaged in a motor imagery task in which the posture of the displayed drawings of the hands and the posture of the hand of the participant making the response were congruent. It was hypothesized that this postural congruency would facilitate motor imagery in participants with right hemiparesis. Participants had to make laterality judgments as quickly as possible upon appearance of the rotated stimuli (i.e., hands) on a screen. The results showed significant linear effects of rotation angle on reaction times for all three groups. In addition, the number of errors made was far below chance level. These findings suggest that motor imagery in right hemiparesis is still intact, but is critically dependent on the congruency between posture of the stimulus and posture of the hand making the response. Furthermore, the influence of hand posture on motor imagery shows that motor imagery is an embodied cognitive process.

Reference

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Delay's Effect on Reversal Movements of Elbow—Comparison of Healthy Subjects and Parkinson Disease Patients

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This study investigated the effects of special conditions like aging and Parkinson's disease on control of reversal movements of the elbow joint performed with a

variable delay between the two components (M1 and M2) of reversal. Another aim was to verify if the stretch-shortening cycle (SSC) exerts potentiating effects on muscular contraction in this population. Twelve volunteers were recruited. Six healthy subjects (3 males and 3 females) between 51 and 71 years of age (Mean = 62.33; SD = 8.95), and six (3 males and 3 females) patients with Parkinson's disease (PD) with ages between 59 and 77 years (Mean = 68.66 and SD = 7.47). They executed fast single-joint movements with a reversal, moving towards a target (M1) and getting back to the initial position (M2). Three different distances (20º, 40º and 60º) were tested and between the two components of reversal (M1 and M2) there were variable delays (0 s, 0.2 s, 0.5 s and 1 s). Elbow angle was recorded using a system of motion analysis (OPTOTRAK 3020) and the electrical activity of braquioradialis (BRR) and lateral head of triceps brachi (TR) muscles were recorded by an EMG amplifier DelSYS (model DE2.2L) with surface electrodes. Aging did not affect the EMG patterns used by subjects in activating the agonist and antagonist muscles to accomplish single-joint movements with a delay. The velocity of movements executed by elderly volunteers was lower because the same strategy applied to healthy persons was used, but with less EMG activity. The PD volunteers moved more slowly than the healthy elderly subjects due to alterations in the modulation of EMG activity. Although they kept the triphasic pattern, EMG showed multiple bursts that alternated during the task accomplishment, which decreased the amount of electrical activity. Besides, they did not reduce the magnitude of second agonist burst in the reversal movements without delay, which made the reversion more difficult. Finally, PD patients showed less relaxation of their muscles during T3-T4, and started the return movement needing more TR activity to produce the same velocity. Movements that reverted without delay showed higher values of second peak, even to PD patients, sustaining the potentiating action of SSC over the triceps muscle. This effect comes from the influence of reflexes and the muscle-tendon storage of elastic energy in the eccentric phase of SSC, which are released at the return phase.

Motor Disorders in Alzheimer's Disease and Mild Cognitive Impairment

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Although some studies reported akinetic features in a significant percentage of patients, motor disorders in Alzheimer's disease (AD) and mild cognitive impairment (MCI) are rarely taken into account in clinical practice, indeed regarded as diagnostic criterion of exclusion. This study was interested in this somewhat paradoxal situation by evaluating in a detailed way the motor efficiency of AD

and MCI patients. *Method*: AD patients (N = 13), MCI patients (N = 19) and control (CTRL) subjects (N = 23) were evaluated using the Purdue Pegboard and a digitizing tablet-based instrument. The four tasks of Purdue Pegboard—dominant hand, non-dominant hand, both hands, assembly—were administered. The tasks of digitizing tablet-based instrument—execution, speed programming, speed-accuracy programming, planning—were performed with dominant and non-dominant hands. Temporal, spatial and sequential constraints underlying these tasks allowed the study to focus, with distinct measures, on the diversified aspects of akinesia, including bradykinesia, hypometria and altered sequential movements. *Results*: Except for the dominant hand task, the Purdue Pegboard results were systematically better for CTRL subjects compared to MCI patients. Except for the assembly task, they were significantly better for MCI patients compared to AD patients. With regard to the assembly task and AD, we did not carry out inferential statistics because of the limited sample (N = 3, 76% failure). Concerning the digitizing tablet, analyses of movement time in a typical speed-accuracy trade-off setting did not reveal any significant slowing of MCI patients compared to CTRL subjects. Movement time was significantly longer for the non-dominant hand of AD patients compared to MCI patients, and constantly longer for AD patients compared to CTRL subjects. Results concerning constant error did not reveal any hypometria, but on the contrary a general tendency toward target center overshoot. This tendency was significantly higher for AD patients compared to MCI patients and CTRL subjects only for dominant hand movements in a condition with poor spatial constraints. Sequencing difficulties were exemplified in planning tasks by a significantly higher effective capacity for CTRL subjects compared to MCI patients. No inferential statistics were carried out for AD patients because of the high rate of failure in this task (54% for dominant hand, N = 6, and 69% for non-dominant hand, N = 4). *Conclusion*: These results confirm the presence of motor disorders in AD and MCI, showing bradykinetic components and altered sequential movements. Above all, they strongly support the idea that motor disorders should not be regarded any more as a diagnostic criterion of exclusion.

Finger Torque Strength and Control in Patients with Parkinson's Disease

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Previous studies have suggested that Parkinson's disease (PD) patients have difficulties controlling isometric force production because of malfunction in the basal ganglia and its cortical intermediaries. It has been found that PD patients show higher variability in controlling finger forces during pressing and pinching grip tasks. However, difficulties in everyday manipulation tasks are not only related to linear force control, but also associated with rotation force (torque) control in these tasks. In this study, we investigated the performances of PD patients in (a) producing maximum thumb-index pinching torque, and (b) controlling constant thumb-index finger torque. Five patients with PD, five elderly and five young, participated in the experiments. All were right-handed based on the task of everyday activities such as writing and eating. Subjects were asked to perform two tasks:

maximum voluntary thumb-index pinching torque production (MVT) and constant isometric thumb-index torque production at 40% of their MVC for 20 s (CONST). For MVT tasks, subjects were instructed to twist the handle as hard as they could. For CONST tasks, a fixed horizontal line was displayed on the oscilloscope screen indicating the target torque. Another moving horizontal line indicating the torque produced by the subject was shown on the same screen as online feedback. Each trial started with a "get ready" signal, and the subjects were instructed to match the line showing the torque being produced by them to the target torque. The instant peak torque was selected as the maximum torque from MVT tasks. Coefficient of variation (CV = standard deviation/mean) was computed over the last 15 s as an index of force or torque variability for CONST tasks. The results from MVT task showed a decreased ability of PD patients to produce maximum thumb-index torque as compared with elderly healthy subjects and young adults while the maximum thumb-index torque production did not differ between young and elderly. The results from constant thumb-index finger torque production during the CONST task showed decreased capability of isometric torque control in PD patients. This result complements the previous studies on pressing and pinching force tasks which showed decreased ability of finger force control in PD patients. The findings suggest that the basal ganglia deficits are related to the maximum finger torque production and sub-maximum torque control during visuo-motor feedback tasks. The deficiencies in PD may be related to the neural mechanisms that might underlie this pathological disruption.

Kinematic, Kinetic and Electromyography Patterns of Standing Up in Parkinson's Disease

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Standing up is a usual task in daily life activities, and it can be limited in Parkinson's disease patients with postural control deficits. The aim of the study was to explore the electromyography, kinetics and kinematics patterns during standing in healthy individuals and in Parkinson's disease patients. Sixteen patients (8 healthy individuals and 8 Parkinson's disease patients) participated in this study, standing, as fast as possible, from a chair. The linear and angular displacement of involved segments, the electromyography activity of tibialis anterior, soleus, vastus medialis oblique, biceps femoris, erector spinae were collected. The data, including knee and ankle torque, were calculated with Matlab software. Although some results indicated similar patterns in both groups, Parkinson's disease subjects did not perform the standing up as well as healthy subjects. They showed increased knee torque values ($p < 0.05$), their knee angles were more flexed than healthy subjects ($p < 0.05$) and they also produced smaller linear displacement in the sagittal plane ($p < 0.05$). Such behavior can be explained by the typical flexed posture observed in the presence of Parkinson's disease. Another aspect is the rigid posture which contributed to muscle retraction. These factors give rise to a flexed knee and then, the knee torque increased in the final movement phases. Trying to decrease this knee torque, the soleus activity changed in the Parkinsonians ($p < 0.05$). It seems to compensate the vastus medialis oblique function. All data suggest that the Parkinsonian with moderate evolvement uses different patterns to perform the standing up, determined by the structural postural changes.

Gender Differences During Downward Squatting

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The gender differences related to the movement strategies in the lower extremity have been investigated frequently in the scientific literature. The use of squatting in rehabilitation programs is one approach to apply the exercises in a closed kinetic chain. The motor strategy was studied recently in subjects with and without patellofemoral pain syndrome (PFPS) during downward squatting. The results showed differences in the kinetic and electromyography (EMG) patterns, which suggested a protecting strategy of the patellofemoral joint in subjects with PFPS. Since females presented a larger incidence of PFPS, this study tested the hypothesis that there are gender differences in the kinematic, kinetic and EMG patterns during downward squatting. Sixteen healthy subjects (8 females and 8 males) participated in the study. They was asked to perform half squatting (0° to 70° of the knee flexion), with restriction of movements in the sagittal plane. EMG responses of the vastus medialis oblique, vastus medialis longus, vastus lateralis, biceps femoris, gastrocnemius lateralis and tibialis anterior were registered. For the analysis of the movement, LEDs were fixed in the center of the joints of the shoulder, hip, knee and ankle and registered by a three-dimensional optical system. A force plate registered the reaction forces. The center of pressure (COP) was calculated and reported as a percentage of the longitudinal foot length. The knee and ankle joint torques was calculated by inverse dynamics. The average displacement of COP, of the torques, and of the EMG signals was calculated in eight phases of the movement based on the knee and ankle velocities. The groups presented the same kinematic behavior (linear and angular displacements). However, compared to females, the males had larger ankle joint torque and smaller knee joint torque. Also, the EMG activity of the components of the quadriceps was smaller in the females than in the males. This suggests that females have increased patellofemoral stress. The gender differences observed suggest that the major incidence in females can be explained partly by the kinetic and EMG patterns.

Case Studies in Dynamic Touch: Stroke and Peripheral Neuropathy

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Perception of spatial properties of objects that are wielded out of view seems to be constrained by the moments of the objects' mass distributions, independent of both sensations resulting from tissue contact (Carello et al., 1992) and the neuromuscular patterning secondary to the kinematics of wielding (Solomon et al., 1989). We further examined this hypothesis by asking whether an individual affected by peripheral neuropathy—presenting with loss of discriminative touch in the left arm— and another one affected by a chronic movement disorder secondary to stroke—presenting with atypical movement kinematics—could accurately perceive the lengths of hand-held objects. The two participants were asked to wield rods of

different extents and mass distributions and estimate their length. At the time of the experiment, the individual affected by neuropathy could not feel that the rods were in her affect hand. But she could close her hand, thereby grasping them tightly, and she could wield on request. The one affected by stroke, in contrast, was significantly restricted in the movements he could make. Moreover, he was able neither to grasp the rods tightly in his affected hand nor to wield them about the wrist (which is the standard methodology). Exploration of the rods was accomplished by securing them to his hand with an elastic band; wielding was performed primarily through shoulder movements. Results indicate that the accuracy and reliability of the affected limbs of both participants were equivalent to those of the unaffected limb and compare favorably to performance by individuals without movement disorders. Moreover, perceived length was affected appropriately by manipulation of the mass distribution. These results indicate that extracting invariants of tissue deformation specific to the to-be-perceived property does not depend on the particular neuromuscular patterning associated with movement or on the presence of discriminative touch. These findings lend further support to Gibson's (1979) hypothesis that perception is not sensation-based.

The Benefit of Neuromuscular Electrical Stimulation on Upper Extremity H-Reflex Excitability Post-Stroke

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Stroke causes severe neuromuscular impairments. Therefore, it is important to develop and optimize treatments in order to effectively assist with the recovery of function following stroke. Understanding the neural mechanism underlying interventions such as neuromuscular electrical stimulation (NMES) is important after stroke injury. The purpose of this Phase I clinical intervention is to assess the benefit of NMES on upper extremity (UE) reflex excitability as measured by the Hoffman reflex ("H-reflex") post-stroke. *Methods*: Five chronic stroke survivors (Intervention Group; 65 +/- 8 yrs) underwent ten days of NMES sequentially applied to their impaired wrist extensors and flexors (30 min/day; 300 us pulse width; 6 s contraction time; 24 s rest). H-reflex and M waveform measurements of the flexor carpi radialis (FCR) and extensor carpi radialis (ECR) were performed prior to (Baseline), immediately following treatment ("Post"), and retention ("Retention"). These measurements were compared to a group of stroke "Control" subjects (n = 5.61 +/- 9 yrs) who performed daily stretching exercises for 10 days. The H-reflex and M-wave were electrically evoked (Digitimer, Inc.) via median (FCR) and radial (ECR) nerves. EMG responses (Delsys, Inc.) were recorded (10000 Hz) for off-line analysis. Recruitment curves were obtained by increasing stimulus intensities from the initial H-reflex threshold through the maximum M wave, as measured by peak-to-peak amplitude (Schindler-Ivens et al). H-reflex recruitment curves were

normalized to the maximum M wave, and then the peak of the H-reflex recruitment curve (Hmax) was calculated. *Results*: Baseline H-reflex and M-wave measures, including Hmax, showed high reliability (3-day measures; ICC = .81) in the FCR and ECR muscles. *Intervention*: Immediately following intervention, the Hmax increased 40.3% (+/- 14%) in the ECR muscle compared to only 5% (+/- 4.1%) for FCR muscle. At retention, Hmax decreased to 8.7% (+/- 3.8%) above baseline levels for ECR, while FCR returned to baseline levels. *Control*: Hmax increased 7.9% (+/- 3.2%) for ECR and 3% (+/- 4.7%) for FCR following intervention, but immediately returned to baseline levels. *Conclusions*: NMES benefits depend upon the UE muscle. ECR showed increased reflex excitability in the ECR, while essentially no change is produced in FCR. This increase in ECR Hmax far surpassed that of the Control group for the same muscle. Increasing the excitability of the H-reflex potentially can lead to improvements in voluntary muscle activation of the wrist extensors. Further investigations of increased duration of NMES across the ranges of stroke severity seem warranted.

Sensory Motor Integration After Early Brain Damage

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Introduction: A universally accepted definition of functional and neural development does not exist. However, most people agree that sensory-motor organization is modular and hierarchical. But the outcome of the lesions that occur early in life is not comparable with those in adulthood (Rushmore & Payne, 2004). In this perspective the study of the early damage effects on functional specialization and development is paradigmatic. *Subject*: We report on a 4.6 year old girl "IS" born prematurely at 30 weeks. At this time she showed difficulty in visual recognition of her parents and of unfamiliar objects and in navigating in unfamiliar space. We studied "IS" with MRI, DTI, and with standardized instruments exploring visuo-perceptual performance and visual recognition. We also studied visually guided action: reaching, grasping and stepping over an obstacle and threshold using a movement analysis system (Vicon 512). *Results*: MRI scans disclosed absence of occipital pole bilaterally, occipitotemporal regions in the right hemisphere and occipitoparietal regions in the left. It was hypothesized that the visual system was characterized by two different streams: the ventral (visual identification of objects) and the dorsal (spatial control of goal directed movement) (Milner & Goodale, 1993). The lesion involved both streams bilaterally with absence of V1, V2 and V3 areas; the right ventral stream (V4); and the left dorsal stream (V3a and V6, and the medial part of superior parietal lobule). DTI images revealed an asymmetrical representation of longitudinal fibers in parietal and temporal areas and very atrophic splenial fibers. Despite the above mentioned difficulties, the subject was able to recognize familiar objects, and in the discrimination of shape and in drawing. She was very skilled in reaching and grasping objects of different shapes and dimensions so as in orienting her wrist to match differently oriented targets. In free space the presence of curbs produced walking hesitation, while in known space she navigated crossing obstacles with little differences from the control group (reduced toe clearance and excessive hip and knee flexion of trailing limb).

Discussion and Conclusion: Considering the selectivity and the extension of the lesion, visuo-motor performance was unexpected. The lesion did not stop brain maturation but induced the development of an original brain, however oriented to the organism-environment matching. The auto reparative potential of the immature brain led to the hypothesis that brain development is a thermodynamic process constrained by a complex or strange attractor. Although the variables of this attractor are not known, they concern the organism-environment relationship as shown by these results. Specific and earlier rehabilitative experiences could improve the process of functional maturation.

Limits of Stability of Individuals with Parkinson's Disease

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Introduction: Postural instability has been considered one of the main features of Parkinson's disease (PD). Balance failure, apparent in postural instability of Parkinsonians, is believed to be correlated with impairments to control voluntary movements of center of mass (CM) over the base of support. Quantification of limits of stability may provide an important component of balance, since its reduction can affect the ability to perform daily tasks. *Objective*: To determine if limits of stability in normal upright stance varied in individuals with PD. *Methods*: A group of 12 individuals with idiopathic PD, aged 69.7 ± 7.0 years and 12 control subjects aged 69.42 ± 7.74 years, matched by body mass index and gender were included in the study. Percentage of body weight supported by each leg in upright stance was determined using the weight bearing test. Movement velocity (MV), maximal excursion (ME) and directional control (DC) of CM in forward, backward, right, and left directions were quantified by the limits of stability test of the Balance Master System. Since most variables related to MV, ME and DC did not have normal distributions, Mann-Whitney-U tests were used to investigate differences between PD and control group, at a significance level of $\alpha < 0.05$. *Results and Discussion*: No significant differences between groups were found for percentages of body weight supported by the lower limbs. However, PD subjects demonstrated significant decreases in movement velocity in all directions. These findings were expected since bradykinesia, a typical feature of subjects with PD, prevents them from rapidly developing the muscular activation necessary to generate ground forces. Reductions in MV decrease the reaction forces and minimize the need for postural stability, which can be advantageous for subjects with PD. ME and DC were also significantly different in backward, right and left directions. Decreases in ME observed in PD subjects might be related to the presence of rigidity associated with reduced postural reactions, as well as changes in motor control, such as muscular co-activation between agonists and antagonists. It is possible that increases in the oscillations observed for the PD group occurred due to greater activity of reciprocal inhibition mechanisms, as previously observed in postural muscles of individuals with PD. *Conclusions*: The findings suggest that in a normal upright stance, limits of stability of subjects with PD were decreased in the backward, right and left directions.

Relationship of Lower-Limb Muscle Torque and Locomotor Performance in People with Parkinson's Disease

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Introduction: Parkinson's disease (PD) is a chronic and degenerative disorder of the basal ganglia that causes bradykinesia, tremor, rigidity and postural instability. Subjects with PD also show asymmetric muscle weakness and disorders in functional activities, such as in gait and in stair climbing. Few studies have focused the relationship between muscle torque and functional performance in Parkinsonians. *Objective*: The aim of this study was to identify which muscle groups in the lower limbs are best predictors of gait speed and stair-climbing speed in people with PD. *Methods*: Seventeen subjects with idiopathic PD who were able to walk and climb stairs independently participated in this study. Participants were separated into two groups (mild and moderate) according to the Hoehn and Yahr Modified Scale. Mean outcome measures included self-selected gait speed, stair-climbing speed and bilateral maximum isometric muscle torque of hip flexors and extensors, knee flexors and extensors and ankle dorsiflexors and plantarflexors. Maximum isometric muscle torque was measured with a hand-held dynamometer while time spent to walk through the walkway and to climb stairs was measured with a digital stopwatch. For each subject, the lower limb with lowest torque values was classified as "the weakest limb." Descriptive statistics and stepwise multiple regression analysis were carried out for data analysis. *Results*: Mean age of subjects and mean time since onset of disease were, respectively, 60.41 ± 9.82 years and 5.58 ± 3.30 years. Mean gait speed was 1.12 ± 0.23 m/s and mean stair-climbing speed was 83.04 ± 24.13 stairs/s. All subjects demonstrated a significant difference in muscle torque between lower limbs. In the moderate group, regression analysis revealed that isometric torque of hip flexors of the weakest limb was the most important independent variable for predicting gait speed ($R2 = 0.78$) and stair-climbing speed ($R2 = 0.73$). There was no relationship between the variables studied in the mild group. *Conclusions*: Muscle weakness is an important aspect of functional performance for patients with PD. For moderated Parkinsonian individuals, isometric muscle torque of hip flexors of the weakest limb explained 78% and 73% of the variability in gait and in stair climbing speeds, respectively. Future studies should verify if gains in strength of hip flexors of the weakest limb could improve gait and stair-climbing speeds in people with PD.

Kinetic and Kinematic Characteristics of Poor and Good Handwriting

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Aim: A proficient handwriting is when a legible text is produced at a minimum of effort. A number of studies involving children demonstrating proficient and poor handwriting have shown differences in the dynamics of such fine motor skill (Van Doorn; Keuss, 1990; Smits-Engelsman and Van Galen, 1997), in contrast others

have not shown such differences (e.g., Smits-Engelsman et al., 2001). Although studies of handwriting have focused on understanding the kinetic and kinematic profiles of handwriting skill, further study is still needed to determine how these profiles are related to the quality of the produced handwriting. The aim of this study was to examine whether the quality of the produced handwriting is associated with alterations in kinetic and kinematic features in children with and without handwriting difficulties. *Method*: Participants were 18 students, 7-8 years of age. Nine were assigned by their class teachers as non-proficient handwriters (NPH), and the other 9 were students matched on age, gender and handedness identified as proficient handwriters (PH). Handwriting quality was evaluated by the Minnesota Handwriting Assessment (MHA) adapted to the Portuguese language. The dependent variables of the MHA were legibility, form, alignment, size, and spacing. Kinetic and kinematic features were evaluated by a writing tasks that consisted of short strings of connected letters ("emem") in two different sizes (3 and 6 mm), performed on a computer graphic tablet (Intuos2, Wacom) The dependent variables of the kinetic and kinematic profiles were averages of pen pressure, number of pen lifts, movement time, number of strokes, number of acceleration peaks, maximum and average jerks, and maximum and average velocity. *Results*: As expected, all variables in the handwriting quality were significantly higher for PH than for NPH. For kinetic and kinematic profiles there were differences between NPH and PH, however, only movement time and maximum velocity reached level of significance, ($z = 2.03$; $p < 0.05$), and ($z = -2.7815$; $p < .05$), respectively. *Discussion*: The results of the present study showed PH is capable of producing cursive writing task in shorter time than NPH. These results are in part explained by the fact that PH children were more fluent in their handwriting as they showed a lower number of pen lifts. Furthermore, PH children exhibit more ballistic movements during cursive handwriting than NPH, which facilitates fluency and smoothness of the motor action of handwriting.

Evolution of the Functional Balance of Patients With Parkinson's Disease Submitted to the Physiotherapy in Group

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Objective: To evaluate the evolution of the functional balance of patients with Parkinson's disease (DP) submitted to the physiotherapy in group in FCT - UNESP. *Methods*: Eleven Parkinsonians, nine (81.8%) men had been evaluated in this study and two (18.2%) women. As evaluation instruments they used the Berg Balance Scale (BBS) and Degree of Disability or Hoehn and Yahr Scale. One proceeded simple descriptive statistics, Wilcoxon's test, Spearman's coefficient of correlation (ρ), with level of significance fixed at 5% ($\alpha = 0.05$). *Results*: The average age was 65.45 ± 8.23 years; the average time of illness was 7.36 ± 5.54 years. BBS scores of the three evaluations had been, respectively, 49.91 ± 7.54; 50.00 ± 7.87 and 46.36 ± 14.30. It did not have difference significant statistics enters the evaluations in the analysis of the subjects in both groups. *Conclusions*: The patients submitted to the program of exercises in this study presented a good motor performance capable to keep the score in the BBS at the three moments of evaluation.

Primary and Secondary Deficits Determinants for Balance Disorders in Parkinson's Disease

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Postural instability is one of the clinical signals that frequently cause loss of physical capability in individuals with Parkinson's disease (PD), however its origin still remains unknown. Therefore, we investigated whether primary factors related to the disease such as rigidity, bradykinesia and bent posture would compromise the range of movement (ROM) in the lower limbs that could further prejudice the postural control. Twelve subjects with PD (Hoehn and Yard 1-3) and 15 healthy subjects with the same age and sex as the control group were assessed. The subjects had their ROM of hips and ankles measured using goniometry and then were submitted to the Postural Stress Test – PST (Wolfson et al., 1986), in which there are external disturbances proportional to body weight, at the shoulders and waist. Then, it was verified the correlation between these data and some scores of characteristic postural control of PD from the Unified Parkinson Disease Rating Scale (UPDRS): the total score, the motor condition score (part C), and isolated scores such as rigidity (question 22), posture (question 28) and bradykenesia/hypokinesia (question 31). It was verified that the PD subjects have significantly compromised ankle and hip ROM when compared with the healthy subjects (dorsiflexion, $p = 0.044$; plantiflexion, $p < 0.001$; hip flexion, $p = 0.035$, hip extension, $p < 0.001$), besides the dorsiflexion and hip extension were directly correlated to the grade of compromise of all the data obtained in the UPDRS, except for posture. In relation to postural control, only the results of the posterior disturbance in shoulders at the PST were statistically different from the control group, being these data also correlated to the UPDRS scores ($p < 0.05$). There was also a positive correlation trend between the ROM compromising in the inferior limbs and the postural imbalance ($p = 0.07$). The present study showed that there are real ROM reductions in the lower limbs as secondary deficits of PD, and identified some factors such as bradikinesia, rigidity and motor and general compromising grade that are determinant for this muscular-articular deficit and for the postural instability observed in people with PD. We believe that we could find a significant correlation between these ROM deficits and the balance disorder characteristic of these patients increasing the number of subjects assessed. Our results allow a better comprehension of the origin of postural instability in individuals with PD, with implications for physical therapy intervention.

Adaptation to New Sensorimotor Mappings in Individuals Who Stutter

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Numerous studies have investigated how human subjects learn to perform accurate reaching movements when the relationship between motion path and visual feedback is experimentally altered. The accumulated knowledge about normal sensorimotor

functioning now provides a strong empirical foundation for hypothesis-driven studies investigating deficits in such sensorimotor learning in patients with movement disorders. Previous theoretical work regarding neuromotor control for speech has suggested that stuttering may be a disorder that is specifically related to difficulties with learning sensorimotor transformations. Interestingly, stuttering is not only associated with speech motor disruptions but also with more subtle differences in the performance of some nonspeech motor tasks. Here, we report new data addressing whether stuttering and nonstuttering individuals differ in the learning of novel sensorimotor transformations when performing nonspeech movements. Stuttering and age/gender-matched nonstuttering subjects reached with the dominant arm to eight visual targets presented in a virtual environment that prevented vision of the hand. Visual stimuli (start, target, and a cursor representing hand position) were projected in the horizontal plane, and the arm was supported by air sleds. Test sessions consisted of three phases: (1) pre-exposure trials performed in the null condition (position of the cursor accurately reflected actual position of the hand), (2) adaptation trials performed while the position of the cursor was rotated counterclockwise around the start position, and (3) after-effects trials performed when the null condition was restored. Preliminary data were also collected to determine the influence of suddenly versus gradually introducing the visuomotor rotation. Previously reported results from other laboratories suggest that basal ganglia and cerebellar lesions have a differential effect on patients' ability to adapt to sudden versus gradual distortions, and both the basal ganglia and the cerebellum have been implicated in theoretical models of stuttering. Data presentation will focus on comparisons of stuttering and nonstuttering subjects in terms of (1) movement accuracy during early adaptation trials when the altered visuomotor mapping has not yet been learned, (2) the time course and extent of adaptation as indices of subjects' ability to acquire a representation of the altered visuomotor mapping, and (3) the time course and extent of after-effects when the null condition is restored as additional measures confirming actual learning of the previously experienced visuomotor environment. Overall, findings will be discussed in the context of theoretical models of the neural control of movement as well as a theoretical model of the neural substrates and sensorimotor mechanisms underlying stuttering. (Funded by the Donaghue Medical Research Foundation.)

The Influence of Fixational Eye Movements on Intention Tremor in ms

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Patients with multiple sclerosis (MS) often manifest movement deficits caused by infratentorial brain lesions. As the cerebellum and brain stem play an important

role in the ocular and manual movement control, MS patients with intention tremor serve as a pathological model for investigating eye-hand coordination. By comparing coordinated eye-hand and isolated eye or hand tracking, our previous study showed abnormalities in ocular and manual movements, and interactions between both motor systems. In the present study, we investigate the influence of the magnitude of the primary saccadic and hand movements on fixational eye movements and hand tremor severity during visually guided step-trackings. Eye and hand tracking movements were recorded in 14 MS patients with intention tremor and compared with those of 14 healthy controls. Results showed that fixational eye movements around the stationary visual targets were larger in the patient than in the control group. In the patient group only, the size of fixational eye movements decreased when the magnitude of the preceding saccadic movement was reduced. Meanwhile, the overall hand tremor amplitude reduced, but the reduction was independent from the decrease in magnitude of the primary hand movement. These findings indicate that the reduction of tremor amplitude may specifically result from the improved visual fixation on the targets when the magnitude of the preceding saccadic movements is reduced. We conclude that, in a coordinated eye-hand visuomotor task, the severity of intention tremor is likely influenced by unsteady gaze fixation on the visual targets.

Gait Kinematic Predictors for Functional Capacity Tests in Parkinson's Disease Patients

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Gait characteristics of Parkinson's disease (PD) patients prevent them from walking adaptively in everyday situations. In both agility/dynamic balance (ADB) and general aerobic resistance and walking ability (ARW) tests of the AAHPERD battery of functional capacity, walking adaptively is required. Since performance on those tests is measured by time (s), walking speed is indirectly related to performance in ABD and ARW. Could the walking pattern of PD patients affect the performance in both tests? The aim of this study was to determine which gait kinematic variables can predict the performance of ADB and ARW tests in PD patients. Three men and 5 women with PD, clinically evaluated by means of UPDRS and Hoehn and Yahr (H&Y) scales participated. Only patients up to stage 3 of H&Y and with preserved cognitive function were included. First, participants performed the ADB and ARW according to the AAHPERD protocol. Then, they walked on an 8 m pathway at their preferred velocity and a digital camcorder registered stride in the middle of the pathway. Markers were attached on the fifth metatarsal and on the lateral face of the calcaneus of the right limb and on the first metatarsal and on the medial face of the calcaneus of the left limb. The 2D movement reconstructions were done using Dvideow 5.1 software. The kinematic variables (stride length-SL, stride time-ST, cadence-CAD, double support time-DS, single support time-SS, swing time-SW, and stride mean velocity-MV) were calculated by MATLAB version 6.5. All tasks were performed under medication. The data was statistically analyzed using Pearson's correlation and linear regression through SPSS version 10.0. The

Kolmogorov-Smirnov test confirmed normal distribution of the data. The results showed negative correlation between SL and ABD (r = -0.79; $p < 0.05$), CAD and ABD (r = -0.81; $p < 0.05$), MV and ADB (r = -0.86; $p < 0.01$), SL and ARW (r = -0.74; $p < 0.05$), CAD and ARW (r = -0.78; $p < 0.05$), and MV and ARW (r = -0.81; $p < 0.05$). We also found positive correlation between ST and ADB (r = 0.76; $p < 0.05$), DS and ADB (r = 0.91; $p < 0.01$), ST and ARW (r = 0.73; $p < 0.05$), and DS and ARW (r = 0.90; $p < 0.01$). The multiple regression analyses reveals that DS was the only gait kinematic variable that predicts performance on both ADB (R2 = 0.84; $p < 0.01$) and ARW (R2 = 0.81; $p < 0.01$). These results allowed us to conclude that the walking pattern of PD patients affect performance in ADB and ARW tests. (Acknowledgements: FINEP, CNPq, FNS, FAPESP, CAPES.)

Effects of Application Footwear Texture in Balance of Subjects with Multiple Sclerosis

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Context: The alterations of balance in individuals with multiple sclerosis (MS) are most problematic due to association with the difficulty of position change, in remaining in the vertical position and execution of functional activities such as walking and turning, predisposing to falls. Plantar sensibility is an important item in regulating the footsteps during human gait and contributes to postural control aspects. Recently, it has been speculated that footwear or orthosis, due to its capacity to modify the kinematics to articulate, can influence the foot sensorial feedback. *Objective*: To analyze the use of footwear texture (FT) in the static and dynamic balance of patients with MS. *Methods*: The balance was evaluated through the Berg Balance Scale, the Index of the Dynamic Gait and a 10-m timed walk. The patients had been submitted to an initial evaluation of their balance without and with the use of FT. After 30 days of FT the same evaluations had been carried through, and after 2 months of this evaluation, without the use of FT, the patients were reevaluated (follow-up). *Results*: Thirteen patients with average EDSS of 2.5 of the Clinic of Neurology had been evaluated at the Hospital of Clinics (HC) of the State University of Campinas (Unicamp). After 30 days of FT use they showed an improvement of 9.75% in balance according to Berg Balance Scale, 22.47% for the Index of the Dynamic Gait, and, through the 10-m timed walk, the improvements had been: 19.72% for the time walk, 9.57% for the number of steps, 8.13% for the length of the step, 15.4% for speed and 10.43% for cadence. *Conclusion*: The use of FT seems to be efficient as an intervention for improvement of the static and dynamic balance of patients with MS.

Gait Analyses According to the Signs/Symptoms of Parkinson's Disease: Preliminary Data

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Parkinson's disease causes stronger functional changes in automatized movements. The primary signs/symptoms, such as tremor, rigidity and bradykinesia increase fall events also during walking. However, most studies related to gait in Parkinson's disease do not separate the patients according to the signs/symptoms. Therefore, the aim of this study was to analyze the gait parameters of healthy elderly and Parkinson's disease patients according to the amount of signs/symptoms of the disease. Participants were distributed in three groups with similar characteristics for age, gender and lower limb length as following: Control group (n = 3 healthy elderly); PD1 group (n = 3 idiopathic Parkinson's disease patients with only one sign/symptom); and PD2 group (n = 3 idiopathic Parkinson's disease patients with two primary signs/symptoms: tremor + rigidity or bradykinesia). All Parkinson's disease patients were between the stages 1 and 2 of the severity of the disease according to the Hoehn and Yahr Scale and the data collection were done in phase ON of medication. In order to collect kinematics data, passive markers (2.5 cm in diameter) were attached on the following points of the right limb: fifth metatarsal joint and the lateral face of the calcaneus. A digital camcorder (JVC model GR-DVL9800, 60 Hz) was placed in the right sagittal plane in order to record one stride in the middle of the pathway. Each participant performed five trials at their preferred speed on a 5 m long pathway after two practice trials. From the marker trajectories during one stride the following dependent variables were selected: stride length, stride duration and stride velocity. The Kruskal-Wallis analyses revealed a group main effect for stride length (H2 = 31.183; $p < 0.001$), stride duration (H2 = 6.001; $p \leq 0.05$), and stride velocity (H2 = 31.778; $p < 0.001$). Mann-Whitney post hoc tests showed that the PD2 group presented the lower stride length and velocity and higher stride duration than the other groups. The amount of signs/symptoms of Parkinson's disease affects the gait parameters indicating that this amount should be considered in studies about the locomotor pattern of Parkinson's disease patients. (Acknowledgements: FINEP, FAPESP, FNS/MS.)

Translation and Cross-Cultural Adaptation of a Motor Coordination Questionnaire for Brazilian Children

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Introduction: Developmental coordination disorder (DCD) is a common diagnosis, prevalent among 6% of all school children worldwide. Even though many motor development tests are available internationally, there is no standardized instrument to identify motor coordination problems in Brazilian children. *Objective*: The aim of this study was to develop a cross-cultural translation of a 15 item parent questionnaire, the "Developmental Coordination Disorder Questionnaire" (DCDQ), into Portuguese. *Methods*: The translation was conducted according to current guidelines for cross-cultural translation of instruments. The translated questionnaire (DCDQ-Brazil) was completed by the parents of 15 children (14 males, 1 female; mean age 8 y, 10 months) with motor coordination problems and the parents of a

control sample of 30 children with typical development (15 males, mean age 9 y; 15 females, mean age 9 y 2 months). Each child with motor coordination problems was matched by age with two typically developing children. Five parents from each group completed the questionnaire twice, 14 days apart, to examine test-rest reliability. The parent's opinion regarding the quality of the questionnaire was recorded. *Results*: The results indicated that the DCDQ items were relevant and easy to answer and 91% of the Brazilian parents reported no difficulties in completing the questionnaire. Regarding psychometric properties, two items showed limitations, due to cultural differences, and had to be replaced. After item substitution, specificity increased from 0.66 to 0.73 and test-retest reliability from 0.95 to 0.97, internal consistency also increased from 0.91 to 0.92. The final instrument shows good potential to be used as a screening tool for DCD in Brazil, however, further research with a larger sample is needed in order to define norms and confirm the instrument's clinical utility. *Conclusion*: The translation of the DCDQ represents a major advance in the process of identifying and supporting children with motor coordination problems in Brazil. The use of a screening tool that is being standardized translated in different countries will facilitate cross-cultural collaboration and comparison of diverse populations of children.

Motor Control of Inspiratory Capacity in COPD Through Surface Electromyography

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Chronic obstructive pulmonary disease (COPD) is considered an important problem of public health. It is the fourth leading cause of chronic morbidity and mortality around the world, particularly in the United States. The air inspired and expired from the lungs can be measured with spirometry during slow respiration or during forced expiratory movements, in order to classify the COPD degree. Electromyography is becoming a tool to evaluate the respiratory musculature due to the changes in respiratory mechanics and muscular respiratory weariness, because it is more comfortable for the patient, avoiding bigger overloads in each individual's body, imposed by spirometry. The study's objective was to evaluate the inspiratory capacity in COPD through surface electromyography of superior and inferior abdominal muscles. Fifteen volunteers of both sexes between 42 to 73 years of age were divided into two groups: the control group consisted of individuals with normal spirometric performance, having VEF1 80% above forecasted. The COPD group consisted of individuals with spirometric performance compatible with moderate to severe obstruction, having VEF1 60% below forecasted. Once the two groups were identified, recording of the electromyographic activity of superior and inferior abdominal muscles took place, in orthostatic position (upright standing), during the inspiratory capacity. The EMG activity was captured by an EMG System do Brasil Ltda composed of differential double electrode, a bandpass filter at 20 to 1000 Hz, and a subsequent amplification of 50 times with a common mode rejection ratio of 120 dB. The data was sent to a 14-bit A/D converter and sampled at 2000 Hz. A differential double electrode was used, with pre-amplification with 100 times pre-amplification, 25 mm^2 contact area and contacts 10 mm apart.

Sampling frequency was 2000 Hz. The recommendations from the International Society of Electrophysiology and Kinesiology (ISEK) regarding electromyography applications were followed. The results were analyzed using independent *t*-test ($p < 0.05$). No statistically significant difference was observed when comparing the RMS (Root Mean Square) values taken for the superior and inferior abdominal muscles of all volunteers from groups A and B, during the inspiratory capacity. The electromyographic records in both groups showed no alterations between groups during inspiratory capacity, since in the CPOD group, the expiration is no longer passive due to the alterations in the respiratory mechanics, resulting in a paradoxical respiration which makes the patients use actively the abdominal musculature.

Delayed Neuromuscular Response During Shoulder Abduction in Subjects with Subacromial Impingement

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Background: Inadequate neuromuscular response likely impairs the stability and the ability to perform smooth coordinated movement of the joints of the shoulder complex. The assessment of acceleration time and time to peak torque may help to further elucidate if neuromuscular control is impaired in subjects with shoulder impingement during shoulder abduction and allow testing of the effects of therapeutic exercises on improving the muscle performance over time. *Objectives*: To assess neuromuscular response during shoulder abduction in subjects with shoulder impingement. *Subjects*: Thirty-four male subjects were evaluated. The impingement group was composed of 17 assembly line workers (age 31.59 ± 6.40 years) with Neer's stages I and II unilateral shoulder impingement. The duration of shoulder pain was 26.18 ± 31.41 months and the average time of the workers in the industry was 8.06 ± 4.26 years. The control group consisted of 17 healthy and active subjects (age 29.50 ± 6.24 years). All subjects gave their written and informed consent agreement to participate in this study which was conducted according to the Helsinki Statement. *Methods*: Neuromuscular response was evaluated by acceleration time and time to peak torque that were measured bilaterally during isokinetic concentric abduction in the scapular plane, at 60°/s and 180°/s. *Analysis*: A two-way ANOVA was used for the statistical analyses of each variable. A level of 5% was used to determine significant differences. *Results*: The impingement group presented delayed neuromuscular response observed by increased ($p < 0.05$) acceleration time and time to peak torque compared to the control group. There was no limb effect (dominant vs nondominant and involved vs uninvolved, $p > 0.05$) and no interaction between limb effect and group effect ($p > 0.05$). *Conclusion*: The results of this study show new evidence of the presence of disorder during abduction in subjects with shoulder impingement, Neer's stages I and II, and emphasize the relevance of training neuromuscular control in shoulder rehabilitation.

Gait Apraxia in Early and Moderate Alzheimer's Disease

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Objectives: Correlate the presence of gait apraxia with cognitive impairment and severity of individuals with Alzheimer's disease; we also measured the balance and functional independence of every individual. *Materials and Methods*: In total, 90 subjects were evaluated, in which 2 groups were formed with subjects with possible AD (AD1 and AD2), each group with 30 subjects, and one control group (CG) with 30 older subjects not demented. Basic inclusion criteria was age 65 years old or more, home walkers and/or community and had more than 4 years of education. Exclusion criteria was the presence of serious labirintopathy, psychiatric disorder, Parkinson's disease or Parkinsonism, vascular brain disease, peripheral neuropathy, serious rheumatic disease, severe limitation of the visual capacity, deficit in understanding verbal commands and symptomatic orthostatic hypotension. The specific inclusion criteria for groups AD1 and AD2 were a Mini Mental Statement Examination (MMSE) score of 25-19 and Clinical Dementia Rating (CDR) 1 for inclusion in group AD1 and a MMSE score of 18-12 and CDR 2 for inclusion on group AD2. For the cognitive evaluation, dementia severity, functional independence, balance and gait apraxia were used as MMSE scales, CDR, Katz index (KI), Berg Balance Scale (BBS) and assessment walking skills (AWS). *Results*: The individuals in the control group obtained maximal performance on every test. The AD1 individuals showed a higher degree of functional independence compared to the individuals of the AD2 group. The balance of the AD individuals was less accurate than those in the control groups. On the AWS, despite both AD groups performed a score above the cut off, 13% and 33% of the AD1 and AD2 groups, respectively, did not. Inside the AD1 group, when a comparison between those individuals above and below the cut off score on the AWS is made, were verified an MMSE and transferences capacities between two places those that performed statistical significance. In the AD2 group, only BBS was statistically significant between the individuals. Spearman's correlation test from AWS with MMSE and BBS were 0.695 and 0.640, respectively. The sensibility and specificity of the AWS scale, through the ROC curve, were 30% and 100%, respectively. *Conclusions*: Gait apraxic disturbances can be misdiagnosed as balance problems. On AD1 and AD2 groups the cognitive impairment was more pronounced in those individuals who scored under the cut off at the AWS. Frontal lobe involvement could be argued in patients with gait apraxia.

Functional and Morphological Muscle Changes of Lower Limbs Post-Stroke

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Post-stroke individuals experience a reduction of muscular strength and increased stiffness due to the loss of motor units, alterations in the muscle fiber architecture and recruitment, connective tissue proliferation, provoking gait and functional

impairments. The purpose of this study was to evaluate the effect of stroke on the cross-sectional area (CSA) and the average peak torque of extensors and flexor muscles of the knee in chronic hemiparetic subjects comparing paretic and non-paretic limbs. Fifteen subjects (age 55.61 ± 9.07 years) 10 male and 5 female, with chronic stroke (> 6 months) were submitted to nuclear magnetic resonance imaging (Torm 0.5; 0.5 T; TE 26 ms; TR 430 ms) and the CSA (cm^2) was measured in six regions using imaging software. An isokinetic dynamometer (Biodex System III) was used to measure isokinetic muscle strength for bilateral knee extensors and flexors in concentric (CON) and eccentric (ECC) modes. The angular velocities tested were 60°/s and 120°/s. Analysis of the CSA of the hamstring muscles indicated atrophy ($p < 0.05$) only in two muscle sections of the paretic limb compared to the contralateral one. Quadriceps muscle showed atrophy ($p < 0.01$) in all CSA regions of the paretic compared to non-paretic limb. The peak torque of knee flexors and extensors was lower ($p < 0.01$) in the paretic compared to the contralateral one, for both CON and ECC modes at 60°/s and 120°/s, without difference between them. In conclusion, although only the quadriceps muscle presented a general atrophy, there is a similar decrease in the peak torque for both knee extensor and flexor in the paretic limb.

Rehabilitation

Study of Health-Quality of Life Among Chronic Stroke Survivors Living in Diamantina City-Brazil

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Very limited studies are available that assess motor impairments and their relationship with quality of life (QoL) in chronic stroke survivors. Recent data shows that in Brazil, stroke is the first cause of death. According to DATASUS, an institution associated with the federal government, the mortality rates in Diamantina city (Brazil) in 2003 was 45.2/100,000 inhabitants in a population more than 40 years old. For this reason, we observed the need to study the QoL and factors associated with it in hemiplegic subjects, especially in chronic stroke patients. From a total of 58 subjects, we selected 27 with diagnosis of stroke in areas of Health Family Program (HFP) of Diamantina city. Using a structured interview questionnaire, the following items were obtained: gender, physical therapy treatment, physical activity before the episode of stroke, time of stroke, side of hemiplegia, type of gait, use of orthesis, and use of alcoholic drinks and cigars before stroke. Moreover, the patients were questioned with the SF-36 (short form 36-item questionnaire) to measure the QoF after stroke with 0 being the worst score, and 100 the best. Thus, the following results were obtained: 44.4% of the patients were male and 55.6% were female. The average age was 66.2 years old, with average time after stroke of 5.4 years. According to patients analyzed, 23 (85%) people did not practice physical activity before stroke and 11 (41%) patients did not receive physical therapy

at the time of evaluation. Fourteen (52%) people presented damage in left limbs. Fourteen (52%) people showed extra-community gait; six (22%) people community gait; three (11%) patients realized gait under supervision and four (15%) people did not walk. In patients with possibility of gait, eight (30%) patients used some type of orthesis; 59% of patients used cigars and 44% consumed alcoholic drinks before stroke. In the SF-36 item on functional capacity, 19 (70%) patients showed a score less than 50. On the item concerning physical aspects, 85% (23) showed a score less than 50. We concluded that a large number of these patients have impairment of gait and physical-functional aspects related to QoL. This study suggests the inclusion of physical therapy in HFP with the aim of decreasing the negative effects associated with motor deficits, in particular, gait and physical conditioning. Moreover, the knowledge of the profile of these patients will permit the identification of prevention factors in future strokes, as well as improvement or change in health policy strategies in Diamantina city.

Evaluation of Temporospatial Gait Parameters and Quality of Life Following Treadmill Training with Body Weight Support Among Patients with Spinal Cord Injury

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Introduction: In recent years it has become possible to retrain motor activity in patients with partial spinal cord injury, especially for walking. *Objective*: To assess the impact of gait training on treadmill with body weight support, regarding temporospatial parameters and quality of life. *Methods*: Twelve patients of both sexes were evaluated. They had been diagnosed with partial spinal cord injury of traumatic origin at least 12 months earlier. They were able to walk and their motor function below the level of the injury was partially preserved and classified as level C or D. After the initial evaluation, the participants were trained on a treadmill with body weight support, with two sessions per week lasting 30 min each, over a four-month period, thus totaling 30 sessions. The patients' temporospatial gait parameters and quality of life were analyzed before and after the training. *Results*: There were improvements in all the temporospatial parameters evaluated ($p < 0.0001$), but no changes in quality of life were seen ($p > 0.05$). *Conclusion*: Treadmill training with body weight support among patients with spinal cord injury was effective in improving the temporospatial gait parameters, but without changing their quality of life.

Physical Therapy Applied During Working Hours Improves Neuromuscular Response in Workers with Subacromial Impingement Syndrome

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Background: Neuromuscular response seems to play an important role in the development of shoulder impingement. The evaluation of acceleration time can be a valuable tool in testing the effects of therapeutic exercises on improving the sensory-motor control over time. *Objectives*: To assess the effectiveness of a standardized supervised therapeutic program performed during working hours on neuromuscular response in a group of workers with shoulder impingement. *Subjects*: Fourteen male assembly line workers (age 31.93 ± 5.86 years) with unilateral shoulder impingement stages I and II were evaluated. The duration of the shoulder pain was 28.50 ± 33.64 months and the average time of the workers in the industry was 9.07 ± 3.68 years. All subjects gave their written and informed consent to participate in this study which was conducted according to the Helsinki Statement. *Methods*: Neuromuscular response was evaluated by acceleration time measured bilaterally during isokinetic concentric abduction in the scapular plane, at 60°/s and 180°/s. Subjects completed an eight-week intervention program, consisting of cryotherapy, strengthening and stretching exercises, performed twice a week during working hours. The subjects were evaluated pre- and post-intervention. *Analysis*: A two-way ANOVA was used for the statistical analyses of each variable. A level of 5% was used to determine significant differences. *Results*: Acceleration time decreased ($p < 0.05$) in the abduction at 180°/s compared to the pre-intervention period. There was no limb effect (involved versus uninvolved, $p > 0.05$) and no interaction between limb effect and intervention effect ($p > 0.05$). *Conclusion*: An intervention program consisting of cryotherapy, strengthening and stretching exercises performed during working hours can be effective to improve neuromuscular response during shoulder abduction in workers with impingement syndrome stages I and II.

Can Iterative Learning Control Be Used in the Re-Education of Upper Limb Function, Mediated by Functional Electrical Stimulation (FES)?

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Introduction: There is a body of clinical evidence to support the use of functional electrical stimulation (FES) to improve motor control (De Kroon et al., 2002) and theoretical support from neurophysiology (Burridge & Ladouceur, 2001) and motor learning research (Schmidt & Lee, 1999). Iterative learning control has its origins in the control of processes that repetitively perform a task with a view to improving accuracy. The classic example is the area of trajectory following in robotics but can it be usefully applied to neurological rehabilitation? *Method*: To answer this question, the ability of 10 patients to track a 2D pattern using a robot arm over a number of trials is being tested. We are designing an algorithm to control FES of appropriate muscles in terms of timing and amplitude to improve tracking. Subsequently the stimulation will be reduced to encourage optimal voluntary contribution to the task. To achieve this, a model is being created using unimpaired subjects to identify activation patterns with respect to joint positions. This will inform when we need to apply stimulation (although we expect patients to differ due to spasticity). In the initial phase surface EMGs have been collected from triceps, biceps, anterior deltoid, upper, middle and lower trapezius and pectoralis major during nine reaching tasks. The EMG data will identify which muscles to control, be used in the controller, and to compare differences between stroke and unimpaired subjects. The next phase involves collecting data using the robot both with and without stimulation and then applying different control algorithms. *Results*: Surface EMG results and analysis from 10 unimpaired subjects will be presented. Preliminary analysis on EMGs from 8 subjects shows evidence that reciprocal inhibition of upper trapezius occurs during maximum reach. If successful, the concept could be used for other neurological conditions such as cerebral palsy and incomplete spinal injury.

"Make-Believe-Game' languagen" in Physical Treatment of Children with Spastic Hemiplegia

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In the present study we described how the "Make-Believe Game" was applied in physical treatment of children suffering from spastic hemiplegia, who presented resistances to specified techniques accomplishment for their neurological picture. The aim that drove us was to verify if the physiotherapy exercises contextualization, by the use of imaginary situations, made these resistances decrease. We worked, in this study, with three children aged from four to five years, plus six months old. We developed the research in two stages, called, respectively, Multiple Base Line and Intervention. The first consisted of a physiotherapeutic intervention without the "Make-Believe" play context; the second one, the Intervention, was contextualized by the use of the "Make-Believe Game" activities, during therapy. The sessions were filmed and, based on these videos, we computed the Resistance Occurrence frequency checked at each session, already characterized, from a preliminary study, as well as the forms through which they have been manifested. The results showed that the Resistance Absolute Frequency decreased with the "Make-Believe" introduction, evidencing an increase in the session duration since the Multiple Base Line phase. We also tried to verify if the Resistance Average Frequency, per minute, has been affected by the "Make-Believe" introduction, however this did not happen: the session times had as less accelerated rise than the ones observed for the decreasing in the Resistance absolute Frequency, from the first to the second work phase.

We noticed, furthermore, changes in the children's verbalization contents, related to their injured limbs, while in the play time situation. These changes indicated that the children started to relate themselves to their bodies, in the limits of these play contexts, in a completely different way. We tried, throughout these results, to understand which means, present in the "Make-Believe," could be affecting the Resistances. We considered, further, which factors could be acting upon the situation, to increase the sessions' duration.

Aquatic Physiotherapy for Vestibular Rehabilitation in Patients with Unilateral Vestibular Hypofunction

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Purpose: To evaluate the effects of aquatic physiotherapy on individuals with unilateral vestibular hypofunction and to verify the association of therapeutic effects with age, time since symptom onset, and use of antivertiginous medication. *Study Design*: Prospective exploratory study. *Setting*: Tertiary referral center. *Patients*: Twenty-one chronic dizzy patients with uncompensated unilateral vestibular loss. *Intervention*: All patients underwent a regimen of 10 sessions of aquatic physiotherapy for vestibular rehabilitation. *Main Outcome Measures*: Patient's evaluation before and after rehabilitation involved the application of the Brazilian version of the Dizziness Handicap Inventory (DHI), dynamic computerized posturography using the Biodex Balance System Equipment, and the self-perception scale of dizziness intensity. Statistical analysis compared average variables before and after rehabilitation using Student t-test. *Results*: Brazilian DHI total scores were lower after rehabilitation than before ($p = 0.001$). Posturography revealed a reduction in variation of body displacement after rehabilitation in the average stability and anterior/posterior stability indexes ($p = 0.001$) and in the average medial/lateral stability index ($p = 0.003$). Self-perception of dizziness intensity was lower after rehabilitation ($p = 0.001$). There was no association between the other studied variables and rehabilitation therapeutic effects. *Conclusion*: Unilateral vestibular hypofunction patients undergoing aquatic physiotherapy for vestibular rehabilitation presented an improvement in quality of life, body balance and self-perception of dizziness intensity, regardless of age, time since symptom onset and use of antivertiginous medication.

Respiratory Physiotherapy Associated with Motor Physiotherapy in a Patient with Viral Myelopathy and HIV: Case Report

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AIDS is caused by human immunodeficiency virus (HIV), a retrovirus discovered in 1983. Opportunistic diseases, which are developed as a consequence of depression of the host's immunity, generally have an infectious origin, and may be caused by viruses, bacteria, protozoa, fungi and some neoplasiae. This study evaluated the association between motor physiotherapy and respiratory physiotherapy in a patient with AIDS and viral myelopathy. Maximal inspiratory pressure (MIP) and maximal expiratory pressure (MEP), 6-min total wheelchair propulsion and peak expiratory

flow (PEF), were measured. Motor physiotherapy consisted of strengthening exercises, and balance and functional activities. Respiratory physiotherapy training protocol included: (1) inspiratory muscle training, using a Threshold™ for 30 min, and (2) aerobic conditioning, in which the patient sat in his own wheelchair and propelled it for approximately 20 min in each session. The visual analog modified Borg scale was applied, before and after inspiratory muscle training and before and after wheelchair propulsion training, in order to measure dyspnea levels. The measures presented before the training protocol were MIP 60 cm/H_2O, MEP 90 cm/H_2O, PEF 270 l/min and the 6-min total wheelchair propulsion resulted in a distance of 100.21 m. After eight weeks, the following results were observed: MIP 120 cm/H_2O, MEP 100 cm/H_2O, PEF 350 l/min, the 6-min total wheelchair propulsion resulted in a distance of 120 m. Inspiratory and expiratory muscles may be specifically trained in order to improve the muscle strength. Thus, we observed an important increase of respiratory measures, total wheelchair propulsion and improvement of dyspnea sensation during functional activities through respiratory and motor physiotherapy. In conclusion, respiratory physiotherapy associated with motor physiotherapy improved the respiratory muscle strength and aerobic conditioning in this patient.

Improvement in Sensorimotor Function in Adult Cerebral Palsy Using a Computer-Based Home Training Program (Project ULTrA)

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Although cerebral palsy (CP) is considered to be non-progressive, many adults report functional declines across the lifespan. While motor training is effective in adult stroke, the extent to which such interventions can improve function in adults with a lifetime history of motor impairment is unclear. Further, no studies exist which have examined somatosensory function in adult CP despite known changes in sensory cortical areas following limb disuse. This study examined reaching and proprioceptive ability in adult CP, and the effectiveness of a unique, computer-based home training program (Project ULTrA) in improving sensorimotor function. Multi-joint reaching movements were first quantified using 3D motion capture techniques. Proprioceptive ability was assessed using an established position matching paradigm involving matching with the same or opposite arm. Project ULTrA involved 40 min/day of home training for 8 weeks. Multi-joint tasks included pointing to targets using a programmable touch board in which different spatial targets were randomly illuminated, and grasping, transporting and releasing objects from one touch pad to another. Movement time was recorded by each touch pad and transmitted to the laboratory via the internet. Participants also practiced a series of hand exercises including tactile discrimination where the index finger scanned one of several possible patterns of raised pins without vision. The pattern was then selected from several computer-generated options. Hand tasks included stereognosis, object manipulation, and object transport using pincer devices. Tasks were performed by both the affected and less affected hands and data transmitted to the laboratory after each training session. Training was monitored by interactive webcams 3 times per week. Proprioceptive ability in adults with CP was worse compared to controls ($p < 0.05$) with deficits more pronounced in tasks requiring interhemispheric transfer

of reference information. Both the affected and less affected arms took longer to reach the target with reversal times showing marked increases in the CP group ($p < .05$). Preliminary results from the sensorimotor training program have shown within-subject improvement for both multijoint reaching and hand function with the latter showing up to a 50% improvement in specific tasks. These studies show that adults with hemiplegic CP have proprioceptive and motor deficits which affect both arms. Preliminary results demonstrate that short duration sensorimotor training leads to enhanced arm and hand function in adult CP and demonstrate the effectiveness of using internet technology to monitor change throughout the training period. (Supported by a DoED NIDRR grant to SB and an NIH T32 post-doctoral fellowship to CL.)

Biomechanical Gait Analysis of Hemiparetic Patients After Functional Electric Stimulation Application

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Introduction: The cerebral vascular accident (CVA) is one of the pathologies that cause larger attack in the neuromuscular function. Patients with CVA sequel demonstrate difficulties in voluntary motor control, with spasticity the main interference cause. Several therapeutic resources can be instituted to rehabilitate these patients. The electric functional stimulation constitutes an electrotherapist resource that promotes muscular contraction with functional objectives. As the objective of this study was to analyze the gait biomechanics difference on 6 hemiparetic patients divided in two random groups, functional electric stimulation was used in the first group in the triceps sural muscle, the second group in the previous tibiae muscle. This study was conducted 4 times per week, for a 30 min duration over a period of 4 weeks. The patients were pre and post test appraised, using the Cerny protocol used to evaluate the gait, modified Ashworth scale to evaluate the muscular tonus, the manual force test and goniometer to analysis of the ankle movement amplitudes. The obtained balances were submitted to statistical analysis using Student's paired *t*-test. We verified that the first group presented a better result in relation to second group. In agreement with the study, the functional electric stimulation resulted in improvement in spasticity reduction, movement amplitude increase, and gait enhancement.

Neural Strategies Controlling the Shoulder and Arm During a High Reach and Grasp Task in Patients with Mechanical Neck Disorder

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Clinicians concerned with the care and management of patients suffering from chronic neck pain often observe deficits in upper limb function. The purpose of this research was to examine the neural strategies exhibited by these patients during a high reach-and-grasp task in order to assess possible deficits when compared to controls. Patients with mechanical neck disorder (MND) and pain of moderate to severe severity and with upper limb symptoms were referred from physiotherapy

clinics. A total of 9 patients (ages: 21-59) consented to participate and were compared to a series of control subjects ($N = 7$). All studies were performed in a specialized motion assessment laboratory. Electromyographic activity (EMG) was recorded bilaterally from 10 superficial arm muscles during a high-reach task. EMG signals were full-wave rectified, low-pass filtered and normalized to resting values. Cross-correlation analysis of muscle pairs was performed over the 3 min trial to determine the activation strategy adopted by patients and controls. Kinematics of the shoulder, elbow and wrist joints during a repetitive high-height, reach and grasp task acquired through appropriate placement of 4 electromagnetic sensors. Orientation statistics were used to determine the behavior of the shoulder and elbow by observing the variance of the joint movement in space. Patients performed this task on both sides both whilst standing and sitting. All patients completed the task but with difficulty and self-reported pain (VAS; 4-6). Correlations between upper and lower trapezius and between serratus anterior and infraspinatus showed non-significant differences (trends) in patients vs. controls. However patients (but not controls) showed a statistically significant decline in the correlation between upper trapezius and serratus anterior, two muscles important in shoulder girdle stabilization ($p \leq 0.10$). Overall, and as expected, elbow joint movement exhibited more variance than the shoulder in both patients and controls. However patients exhibited more uncoupling of elbow and shoulder joint movement. The disruption in shoulder/elbow coordination was more evident in the sitting task. We propose that these results are evidence of a disruption of the neuromuscular control of the shoulder girdle leading to possible disruption in upper limb coordination. This manifests as progressive shoulder guarding and increased inconsistency in elbow joint movement. This is particularly evident during challenging tasks requiring patients with MND to reach above their heads.

Decreasing Spasticity with Intensive Locomotor Training in Para- and Quadriplegic Patients

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Our program of locomotor recovery for patients with vertebrogenic paralysis routinely included electrostimulation of the midlumbar enlargement resulting in rhythmic alternating leg movements (40-90 min/day); the "propriospinal" stimulation: air-stepping in a parachute system evoked by rhythmic arm movements imitating walking and running (15-30 min/day), treadmill training with partial body weight support (30-40%, 30-40 min/day), tetrapedal walk and kneeling (30-60 min/day or more), and training of vertical posture with a rhythmic displacement of the center of mass in either frontal or sagittal plane (the parachute system without unloading, 20-40 min/day). The total time of passive, simulation-evoked and self-induced motor activity was about 4-8 hours a day depending on the age and functional ability of the patients and stage of rehabilitation. The course of training lasted for 6-10 weeks. In most spastic patients (initial spasticity of 2-3 points on the Ashworth scale), during the course of training we observed a temporary increase in spasticity (up to plus 1 point on the Ashworth scale) during the first week and its smooth

decrease over the next 4-6 weeks up to a level 1-2 points less than the initial level. The spasticity decrease continued for about 3-4 months after the training course ended. No antispastic drugs or other special therapy was used for these patients. We ascribe this effect to the intensive locomotor training. In 5 patients (age 10-19) with high spasticity (4-5 on the Ashworth scale) such training during 4 weeks did not improve spasticity, which limited the treadmill training and disturbed the night sleep. For these patients we additionally used pharmacological locomotor and antispasticity stimulation with combination of clonidine (alfa2-noradrenergic agonist) and cyproheptadine (serotonergic antagonist) following a scheme of Fung et al. (1990). Four of these patients showed a 1-2 point decrease in spasticity and one patient recovered physiological muscle tone. At the end of the course all patients demonstrated improved locomotor and postural capabilities: facilitation and an increase of the step length, higher velocity and distance of treadmill and tetrapedal walk, as well as improved duration and stability of supported standing. All patients needed less help. The patients with incomplete paralysis increased muscle force during voluntary leg muscle contractions. Our experience shows that intensive locomotor training decreases spasticity and improves locomotor ability and force of voluntary leg muscle contraction in paraplegic patients. In cases of strong spasticity additional pharmacological treatment with clonidine and cyproheptadine gives good results.

Functional Electrical Stimulation in the Subluxation of the Shoulder of Carriers of Cronic Stroke

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Introduction: The subluxation of the shoulder is an important and frequent secondary complication found in the patient that has suffered a stroke. In hemiplegia, the paralysis of the muscles of the shoulder, together with the lack of inferior stability of the glenoumeral joint, contributes to the occurrence of the inferior displacement of the head of the humerus. Functional electrical stimulation (FES) is often used as an effective therapeutic resource in the best congruence of the glenohumeral joint, allowing functional improvement and reduction of pain in the joint of the shoulder. *Objective*: To evaluate the effect of the FES in the subluxation of the shoulder, in the radiological and functional aspects and in the pain of patients in chronic phase of the stroke in the physiotherapy sessions. *Methods*: The study was a clinical assay controlled randomized with 6 patients who had carried through RX examinations and had passed for evaluation of pain, evaluation of the superior member (Fugl-Meyer) and physiotherapeutic evaluation. All the measures had been made by a blind appraiser. The patients had been divided in 2 groups, a Control Group (CG) and an Experimental Group (EG). The CG only received conventional physiotherapy in the superior member, while EG received conventional physiotherapy and a program from treatment with FES. *Results*: The comparison enters the measures of ROM, RX, function and pain had no significant difference in the 2 groups before and after the treatment. However, the present study showed that the experimental group experienced a greater reduction of the subluxation and pain in the shoulder, when compared with the control group. *Conclusion*: This study is not conclusive due to

the small number of the sample. However, the FES seems to produce reduction of the subluxation, improve the function of the superior member and to act in the reduction of pain in carrying patients of chronic stroke.

Comparison Between Functional and Non-Functional Exercises in the Recovery of Patients with Motor Sequela for Ischemical Stroke

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Objective: To assess functional and non functional training effects on the motor function of upper limbs in patients after brain stroke. *Patients*: Ten hemiparetic patients with stroke in the medial cerebellar artery territory of at least a year were selected. *Methods*: Two training were compared: non functional (group A, $n = 5$) and functional (group B, $n = 5$) sequences, with repetitions of the paretic hand and the non paretic hand. All patients were assessed by clinical scales: Fugl-Meyer, ARA and modified Barthel in four stages: before treatment, right after treatment, a month and three months after the end of treatment. Group A (control) and group B was trained with 30 sessions of 90 min. The non functional sequence consisted of active or, when needed, assisted-active or passive movements of all upper limb articulations to all directions of movement. The functional sequence consisted of movements simulating daily life activities, such as, clawing, catching, using pliers, and even positions involving all upper limbs such as rolling, prone and four supports. Both sequences were performed bilaterally and with repetitions. The number of repetitions was established from the first session by observing the quantity the patient did in 90 min within his limits. From this moment, the number of repetitions increased as the patient evolved. *Results*: Groups A and B improved their scores in the proposed scales, especially in Fugl-Meyer and ARA. When comparing indexes of both groups we did not find significant differences at any moment in Fugl-Meyer, ARA and modified Barthel scales. *Conclusion*: Our results showed that both treatments improved patients, especially in Fugl-Meyer and ARA scales. Besides, the analysis between both groups showed that changes in scale scores seemed not to be dependent on the applied treatment showing that both trainings were similar as to their effectiveness.

Immediate Effects of Muscular Stretching Exercises on Flexibility, Range of Motion and Pain

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Muscular stretching exercises are commonly applied to increase the length of soft structures that are pathologically shortened and to improve flexibility and joint mobility, thus reducing the possibility of postural alterations. The purpose of this study was to compare the immediate effects of two stretching techniques—passive and hold-relax—on global flexibility, hamstring tightness and pain intensity. Thirty healthy men had been evaluated, with age between 18 and 36 years and hamstring tightness and without muscle skeletal injury in the lower limbs. Before and after

intervention, the following variables were measured: hamstring tightness defined as a loss of knee extension greater than 30 degrees, measured with hip flexed at 90 degrees by a goniometer, global flexibility by the fingertip-to-floor test and pain intensity by a visual analogue scale. The 30 selected subjects had been randomly divided in two groups of 15 subjects: Group 1 (G1) performed passive stretching exercises of the hamstring muscles and Group 2 (G2) hold-relax of the same muscles (the lower limb most shortened was chosen for intervention). In both groups, stretching exercises were repeated five times, with 30 seconds of duration and 30 seconds of rest, in a single session. The variables before and after stretching exercises were analyzed by the Wilcoxon test and between groups by the Anova and Duncan tests or Anova of Friedman ($\alpha < 0.05$). Before and after intervention in both groups, results showed a significant reduction of hamstrings tightness (G1: $p = 0.001$, G2: $p = 0.001$), a significant increase of global flexibility (G1: $p = 0.002$, G2: $p = 0.001$) and no pain intensity modification (G1: $p = 0.952$, G2: $p = 0.053$). Between groups, although there was no significant difference (hamstrings tightness: $p = 0.939$; global flexibility: $p = 0.594$; pain intensity: $p = 0.757$), it may be said that G1 showed the best reduction of hamstrings tightness and G2 tended to increase pain intensity after stretching exercises. The findings of this study can suggest that both stretching techniques are indicated to increase global flexibility and reduce hamstrings tightness. However, considering the presence of muscular pain, passive stretching exercises must be the elected technique because hold-relax can increase pain intensity.

Evaluation of the Functional Capacity, Quality of Life and Pain in Patients with Fibromyalgia Syndrome Submitted to Aquatic Physical Therapy

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Introduction: The fibromyalgia syndrome (FMS) is a chronic, non-inflammatory and painful syndrome observed in musculoskeletal and other systems. Physical exercise is an effective intervention in its treatment; such activity is responsible for bringing back a functional lifestyle. Aquatic physical therapy offers support of these exercises. *Objectives*: To evaluate the functional capacity through the Six Minute Walk Test using group aquatic physical therapy as Study Group (SG) comparing it to a Control Group (CG) which has chosen not practice any physical activity; and correlate this modality of physical activity with quality of life through the Fibromyalgia Impact Questionnaire (FIQ) and pain through Visual Analogue Scale (VAS). *Methods*: The study was composed of 40 patients with FMS, equally divided into two groups. The criteria for inclusion took into consideration a medical diagnosis of FMS, no age and sex restriction, no physical activity, medical authorization to participate in aquatic exercises, and signing terms of acceptance of the process. To the SG was offered aquatic physical therapy associated with the maintenance of medical treatment once a week, during 12 weeks in 40-min sessions. *Results*: The average age of the SG was of 51.42+/-8.17 years and of the CG was of 58.38+/-9.40 years ($p = 0.009$). In relation to distance covered in meters in a period of 6 minutes, FIQ and VAS measures there was no statistical difference between the SG and the CG groups, although the latter have walked further ($p = 0.67$; $p = 0.5$; $p = 0.6$). After 12 weeks, both groups have improved the studied

variables. Between the groups, there was statistical significance only in the variable functional capacity of the SG over the CG ($p = 0.05$). As for the overall quality of life and pain, when the period of protocol is considered, there was only significance in the SG ($p = 0.004$ and $p = 0.001$, respectively). *Discussion*: The progress in the functional capacity of the SG relates to the benefits of the aquatic exercises. The absence of significance to the quality of life and pain between the groups is justified for its subjectivity, for importance and variability of symptoms and the performance of modulating facts. *Conclusion*: The aquatic physical therapy has improved functional capacity, as well as pointing out benefits in the quality of life and pain of the assessed population. Nevertheless, controlled future clinical trials are necessary for a better correlation of those variables.

Electromyographic Analysis of Stroke Patients' Affected-Limb While Cycling On An Arm Ergometer

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One of the behavioral adaptations to environmental demands is a characteristic of the human movement. The interaction between upper limbs can be observed in healthy subjects performing bilateral-cyclical tasks. Motor disturbances followed by a stroke cause stability loss and generate atypical movements. The aim of this study is to analyze biceps and triceps muscle activity (EMG) of the affected limb on stroke patients during movements orchestrated using the arm cycling ergometer for utilizing a function of the bilateral limb usage and their speeds. Two groups, matched by age and gender, participated in the study: Patient Group (6 stroke patients, in average 15 ± 9 months after ischemic stroke in the territory of the middle cerebral artery; mean age: 58 ± 3 years; mean Fugl-Meyer Assessment score: 39.5 ± 14.6) and the Control Group (6 healthy individuals; mean age: 55 ± 3 years). The groups underwent a two-day testing experiment: on the first day all subjects completed a bilateral movement, on the second day only unilateral movements; stroke patients performed with the affected side, and the control group with the non-dominant limb. The order of these two conditions was randomly selected among subjects. Participants started the task at a self-selected comfortable speed, after a 1-min task familiarization and an additional minute of training, the speed was increased by 10% and 20% of its initial value. Each increased speed was maintained for a 1-min interval. Affected limb and non-dominant limb biceps and triceps muscle activities were recorded and compared for the two testing conditions and the three testing speeds. Results showed highest muscle activity at the initial speed as compared to the other two speed conditions ($p = 0.017$). The EMG activity was significantly higher on the affected/non-dominant side for the bilateral condition of cycling when at the comfortable speed compared to the designated increased velocities, as well as the unilateral movement at all speed conditions ($p = 0.004$). The unilateral condition showed no speed dependency. An interaction, marginally significant ($p = 0.057$), was found between tested groups and selected muscles. Patients showed higher biceps muscular activity than the control group and no differences in triceps activity between groups. These EMG activity patterns suggest comfortable upper limb cyclic training can facilitate muscle activity, thus, can benefit the affected limb therapy of hemiparetic patients.

Influence of the Environment on Posture and Gait Parameters After Stroke

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Efficient walking depends on the individual's capacity in adhering to unexpected tasks and environmental difficulties. The stroke patient who experiences a reduction in the ability to walk reveals that the rehabilitation method should include not only a muscular but also an environmental factor. The ability to adapt to a different terrain suggests a correlation with the individual functional capability. Stereotyped and low selective movement patterns are a common stroke eventual effect. Stroke patients demonstrate greater difficulty as their postural control demands increase. The detection of these alterations on such capabilities is relevant for specifying physical therapy treatments and promoting patients' re-adaptation. The purpose of this study is to characterize the motor behavior of stroke patients while walking on unstable ground. Participants consist of stroke patients (experiencing middle cerebral artery lesion and minimum 6 months post-stroke onset) and healthy individuals (control group) matched by age and gender. Participants completed a 10 m walk at a self-selected speed. The study performs a 2D kinematic analysis comparing stable ground and unstable ground (foam mattress: 5 cm thick and 33 kg/m^3 density) at specific gait cycle events (initial contact, mid-stance, pre-swing and mid-swing). Five angles were quantified: (1) shoulder segment (angle formed between the line along the acromions and the horizontal axis), (2) pelvic segment (angle formed between the line along the posterior superior iliac crests and the horizontal axis), (3) ankle (angle between foot and shank segments), (4) knee (angle between shank and thigh segments) and (5) thigh (angle formed between thigh and the horizontal axis). The walking speed, stride length and step length were also measured. Preliminary results showed that stroke patients had a greater variance on the lateral view parameters when compared with the control group. In spite of the patients' motor difficulties the differences between groups were more evident during unstable gait particularly on the mid-stance and pre-swing phases. As expected, patients were slower and showed shorter stride and step length when walking on unstable ground. Initial analysis appears to demonstrate a positive relationship between shoulder and pelvic lines on patients while the control group showed a negative relationship along almost all the gait cycles, that may justify their lower efficiency in adapting to unstable terrain as observed in clinical practice.

Acute Effects from Passive Cyclic Mobilization on Spasticity in Paraplegia Due to Spinal Cord Injury

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Traumatic cord injury is the most frequent mechanism of lesion of the spinal cord, and, if not fatal, carries many sequels, one of which is spasticity. The aim of this research was to analyze the effects of passive cyclic mobilization (PCM) on spasticity and its repercussion on life quality and functionality according to the Nottingham Health Profile (NHP) and the Functional Independence Measure

(FIM), on a paraplegic patient, age 38, neurological level T1. In this study a cycle ergometer was used to allow PCM of lower limbs starting from active movement from upper limbs training, 3 times per week, for 6 weeks (17 sessions). The Ashworth Modified Scale (0 to 4) was applied and surface electromyography associated to the Pendulum Test (number of leg oscillations) were used before and after test as knee extensors spasticity evaluation instruments. Results showed acute knee extensors spasticity reduction that held over 12 to 18 hours after each session. On the Ashworth Modified Scale there was spasticity reduction from grade 3 to grade 1; on the Pendulum Test there was an enhancement from 4 to 8 oscillations in each leg. Electromyographic register made during pendulum test showed a reduction of 49% in right lower limb and 32% in left lower limb. No changes could be seen on life quality and functionality measured with the NHP and FIM scales, respectively. New research is needed to verify retention time of effects on spasticity and possible neurophysiological mechanisms involved.

Postural Global Reeducation and Segmental Static Stretch in Individuals with Temporomandibular Disorder: A Comparative Study

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In myogenic TMD, most patients present pain in the elevator muscles of the mandibula during the palpation or mastication with postural electromyographic activity increased and limitation of movement. Besides this, closer areas like shoulders and the cervical region can present tension, muscle shortening and trigger points. The therapeutic exercises that have been used in rehabilitation and prevention of the myogenic temporomandibular disorders, however, in an integrated form with other resources of the physiotherapy and/or odontology, impede a clear verification of their effects in the TMDs. This study aimed to compare the effects of the postural global reeducation and the segmental static stretch in the treatment of women with myogenic TMD, Helkino III. The intensity of the symptoms was evaluated (Visual Analog Scale) as well as the electromyography of the muscles masseter, temporal, trapezium and sternocleidomastoid. Twenty-eight women were selected and divided randomly into 2 groups. The treatment of group 1 consisted of 2 postures of PGR, one for the anterior chain and the other one for the posterior chain; the treatment of group 2 consisted of segmental stretch for the masticatory muscles, cervical region and upper limbs. Pompage maneuvers were added in both protocols. The two groups had 8 individual weekly sessions, which lasted 40 min each. In the data analysis of each group, the Friedman test was used with a 5% level of significance and among the groups, dispersion diagrams. The results suggest that the two kinds of stretch had the same effectiveness in the symptom relief ($p < 0.005$), decrease in the electromyographic activity in the muscle masseter ($p < 0.005$) after the treatment.

Development and Validation of an Instrument to Measure Bilateral Upper Extremity Function in Patients with Hemiparesis

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The Arm Bilateral Function Test (ABIT) is a new clinical measurement tool for evaluating upper extremity bilateral movement and use following stroke. Arm and hand recovery are possibly the most important challenge for rehabilitation after stroke. Within this problem, some new therapies have been developed in the last several years. Studies on bilateral arm training are increasing in the recent literature concerning stroke motor rehabilitation. On the other hand, instruments used to evaluate functional upper limb functional recovery, have in general, few items concerning bilateral movements, and when this is the case they predominantly graded dexterous use without including proximal arm movements. Some patients lack enough distal recovery to have good scores in these evaluations, however, they can use the affected limb to help the less affected limb even without digit use. This last function is rarely tested in upper limb functional evaluation. The objective of this study was: (1) to create a instrument for evaluation of bilateral functional upper limb use in patients with hemiparesis due to stroke (2) to determine the psychometric proprieties (internal consistency, concurrent validity, intra-rater and inter-rater reliability). The particularity of this instrument is that they include items with proximal and distal movements with different degrees of difficulty and their 13 items evaluating exclusively bilateral tasks. Twenty-eight patients (age 54 ±10 yrs) with chronic hemiparesis (39 ± 36 months) admitted for out-patient rehabilitation and 10 healthy control subjects were included in this study. The study design involved instrument development with judges panels, then intra-rater and inter-rater agreement are assessed using intraclass correlation coefficients based on scoring of videotaped performances. Internal consistency of the test was assessed using the Cronbach alpha. Concurrent validity was assessed using the correlation of the scores with Fugl-Meyer Assessment. Intra-rater: time 1 (T1) × time 2 (T2), and inter-rater: rater 1 (R1) × rater 2 (R2) reliability coefficients were good for the whole scale (respectively ICC = 0.99 and 0.93), and individual items (T1 × T2 - ICC from 0.86 to 0.89 and R1 × R2 - ICC from 0.88 to 0.98). The test discriminated patients with different upper extremity impairment levels according to the Fugl-Meyer motor scores (r = 0.88 to R1 and 0.90 to R2; $p = 0.001$). This result suggests that ABIT is an instrument with high reliability and validity, applicable to patients with hemiparesis due to stroke.

Perception of Quality of Life Through pdq-39 in Brazilian Subjects with Parkinson's Disease

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Introduction: Parkinson's disease (PD) is a chronic and degenerative disease that causes movement disorders and emotional, mental and social problems. Studies that evaluated quality of life (QOL) in Parkinsonians revealed a significant negative impact of this disease. The Parkinson's Disease Questionnaire-39 (PDQ-39) has been nominated as the most appropriate instrument for the evaluation of QOL in persons with PD. So far, no study has evaluated the perception of QOL through PDQ-39 in Brazilian Parkinsonians. *Objective*: To investigate the perception of QOL in Brazilian subjects with PD, using the PDQ-39. *Methods*: Thirty-three subjects with a diagnosis of PD were included in this cross-sectional study. Inclusion criteria consisted of: being over 40 years of age, being classified at stages 1 to 3 of the Hoehn and Yahr Modified Scale; and having no problems in answering the questionnaire. Data of QOL was collected through personal interview with PDQ-39 which is divided into eight dimensions: "Mobility," "Activities of Daily Living" (ADL), "Emotional Well Being," "Stigma," "Social Support," "Cognitions," "Communication" and "Bodily Discomfort." Each item has five options of answers (never, occasionally, sometimes, often and always) with a total score in PDQ-39 ranging from 0 (no problem) to 100 (worst perception of QOL). *Statistical Analysis*: Normality tests and descriptive statistics for all variables. Spearman rank coefficient was calculated to investigate possible associations between dimensions and total score. *Results*: Mean age of subjects and mean duration time of PD were, respectively, 64.65 (± 10.44) and 9.27 (± 4.40) years. The median total score at PDQ-39 was 25%, with worse perceptions of QOL for "ADL" (41.67%) and "Mobility" (34.32%). A high association was found between total score and the dimension "Mobility" ($r = 0.82$) and a moderate association between total score and the dimensions "ADL" ($r = 0.68$) and "Communication" ($r = 0.53$). *Conclusions*: In this study, motor related dimensions of PDQ-39 have shown the worst perception of QOL in Brazilian subjects with PD. Since motor disorders are the main dysfunctions caused by PD, it would be reasonable to expect that dimensions related to motor dysfunctions of PD would have shown worse perceptions of QOL. This is also true for total score in PDQ-39, which was significantly related to scores in "Mobility," "ADL" and "Communication," all dimensions including questions about motor aspects of PD. These findings suggest that addressing motor aspects of PD may be important for changing perception of QOL in Parkinsonians, since improvements in motor related dimensions could be associated with improvements in total score of PDQ-39.

The Effect of Foot Position on the Performance of Sit-to-Stand Movement in Stroke Subjects

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Introduction: Muscular weaknesses contralateral to the injury side are the most common problems of stroke survivors. These individuals have difficulty in performing functional activities, such as the sit-to-stand (STS) movement without assistance. During the period of recovery from a stroke, loading on the affected leg (AL) tends to be spontaneously avoided, leading to difficulties in accomplishing the STS movement and, consequently, compromising the individual's independence.

Distinct strategies can be used to favor weight loading on the AL during STS movement. For instance, backward positioning of the AL is a strategy commonly employed in clinical practice. However, its effect on improving performance with chronic hemiparetic subjects is still lacking. Therefore, the aim of the present study was to investigate the effect of different positions of lower limbs during the STS movement with chronic stroke subjects, by randomly investigating four strategies: (A) spontaneous; (B) symmetrical; (C) asymmetrical-1-affected foot behind; and (D) asymmetrical-2-non-affected foot behind. *Methods*: Twelve chronic hemiparetic subjects participated in this study. Participants were aged between 60 and 80 years, with time since onset of stroke between one and 14 years. For STS movement, the following outcome measures were investigated for the four strategies: differential latency (DIFLAT) and electromyographic (EMG) activity of the tibialis anterior, soleus, quadriceps and hamstring muscles of the AL, as well as movement time (MT) and time of seat-off. Repeated measures ANOVA followed by planned contrasts were employed to investigate the effect of strategies B, C, D in relation to the A strategy. *Results and Discussion*: The results indicated that when compared with the A strategy, soleus showed a greater DIFLAT in the D strategy, while the hamstrings had lower EMG in B strategy. The MT was greater in strategies C and D. Time of seat-off did not differ significantly for the investigated strategies. *Conclusions*: The D strategy appeared to be less favorable to the accomplishment of STS movement, since it increased movement time. The C strategy did not appear advantageous, whereas the B strategy showed little need of stabilization of the affected knee and MT was similar to the A strategy. The spontaneous (A) and the symmetrical (B) strategies appeared to be more favorable in improving the performance of the STS movement with chronic hemiparetic subjects with lower functional impairments.

Perceived Body Vertical in Standing Patients with Stroke

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The ability to maintain posture requires the integration of information from vestibular, visual, and propreoceptive systems. In patients, balance can be affected by many factors including misperception of the visual information, a factor that is commonly found in individuals with visuospatial neglect resulting from cerebral hemispheric stroke. One manifestation of this condition is impaired perception of the position of the body in space, represented by a several degrees tilt of the perceived visual vertical of the body. The assessment of perceived body verticality is usually performed in a dark room when seated subjects manually adjust a luminous rod to the vertical position. However, this protocol is limited to sitting conditions only. Recently we developed a new method that involves assessment of the perceived body vertical in the frontal and sagittal planes while in the standing position. The method is based on using a modified NeuroCom Computerized Dynamic Posturography technique combined with the Biodex Unweighting System. The method was tested in eight individuals who sustained a stroke and who exhibited neglect of their hemiparetic side in conjunction to visuospatial problems (26.8 ± 15.7 days post-stroke, 6 presented with right hemiparesis and 2 with left hemiparesis) and eight healthy control subjects. The subjects were provided with a harness system

(that allowed partial support of their body weight if needed) and were required to identify the perceived verticality of their body in relation to the position of the platform on which they were standing. This was completed as the platform was returning back (velocity 1 degree/s) to a horizontal position after being tilted in a toes up/down or left/right direction by 5 degrees. Platform tilts induced changes in the body verticality either in sagittal or frontal plans. Each subject participated in eight trials and was instructed to identify the moment when he/she felt the body was vertical. Subsequentally, angles between the platform position in sagittal and frontal planes in relation to the horizontal plane were measured. These angles in the sagittal plane were 1.93 ± 0.42 degrees in patients and 0.63 ± 0.27 degrees in controls ($p < 0.01$). Mean angles in the frontal plane were 1.73 ± 0.53 and 0.56 ± 0.05 degrees in patients and controls respectively ($p < 0.05$). The results of the study demonstrate that patients identified perceived body vertical approximately three times worse than control subjects ($p < 0.05$). The outcome of the study suggests that objective measurement of perceived verticality in standing should be used when designing appropriate treatment protocols and monitoring the progress of the rehabilitation of patients with stroke-related visuospatial deficit and balance problems.

Is Electrical Stimulation on Dorsiflexor and Plantarflexor Muscles Better Than Only On Dorsiflexors in Children with Cerebral Palsy?

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Cerebral palsy is a non-progressive disorder which consists of impaired motor function secondary to injury of the immature brain. Motor function of children with cerebral palsy depends on the interaction of spastic agonist muscles with their antagonists and on the balance between these muscular groups. Electrical stimulation is used by physiotherapists to improve muscular force and motor function of these children. The objective of this study was to verify the effect of electrical stimulation on spastic hemiplegic children with cerebral palsy, when applied on dorsiflexor and plantarflexor muscles for improvement of motor performance during activities such as standing up, walking, running and jumping when compared with the use of electrical stimulation only on dorsiflexors. *Materials and Methods*: This study is a pilot of a randomized clinical trial still in development. Eight participants with spastic hemiplegic cerebral palsy were included, with ages between 2 and 9 years, and were divided into two groups: an experimental group (GE) and a control group (GC). Both groups were submitted to functional electrical stimulation twice a week during 8 weeks. The experimental group received functional electrical stimulation on dorsiflexor and plantarflexor muscles while the control group was only stimulated on the dorsiflexors. The participants were assessed before and after intervention. Motor function was measured by the dimensions D and E of the ''Motor Gross Functional Measure'' (GMFM); Spasticity by the Modified Ashworth Scale and range of motion by goniometry. *Results*: Both groups improved their scores in Gross Motor Function Measure dimensions D and E, however, the experimental group presented a more significant improvement. On the Modified

Ashworth Scale, one child of the experimental group increased 1 point, and one had a reduction of 1 point, the other two had no change in spasticity. In the control group three children had reduction of 1 point. Range of motion improved in both groups, however, the experimental group got better results. This study showed benefits in the application of functional electrical stimulation on dorsiflexor and plantarflexor muscles, presenting improvement in the functional activities of children with cerebral palsy. However, the study is still in development, a larger sample being necessary for a reliable result.

Analysis of the Scales of Motor Function in Children with Cerebral Palsy: Literature Revision

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Cerebral palsy belongs to a group of cerebral disorders due to an injury in the immature brain during the first years of life, causing motor alterations responsible for compromising the performance of functional activities. The instruments used to evaluate the motor function in children with cerebral paralysis were: GMFM, PEDI, Melbourne Assessment, Jebsen-Taylor and GMFCS, were applied to optimize the definition of the intervention objectives, compare the effectiveness of treatment and to facilitate communication of the interdisciplinary team. *Objective*: The purpose of this study was to verify, through literature revision, the effectiveness of the evaluation scales of motor function in children with cerebral palsy and to analyze its properties critically. *Methods*: The research and choice of articles were carried out utilizing the Medline, Lilacs, PubMed, Cochrane and Scielo databases, from 1969 to 2006, through the describers of cerebral palsy and motor activity. The enclosed studies have been related to the instruments of evaluation of motor function in children with cerebral palsy and the ones that compared its psychometric properties. The ones that used instruments for some specific intervention were excluded. *Results*: We found 72 articles, and 13 had been enclosed in the revision. The studies relate to psychometric properties of the instruments and compare the scales between themselves. Most of them, seven (7), are on the GMFM, followed by PEDI and GMFCS while few authors mention the Melbourne Assessment and Jebsen-Taylor. *Discussion*: The GMFM is a method used worldwide, and there are many studies that confirm its properties. The PEDI is a reliable validation and it is the only one adapted to Brazilian culture that evaluates the motor function of different forms of the GMFM. Both are distinct methods that applied together complement themselves resulting in a wide range evaluation and a possible prognosis if associated with the GMFCS. The other methods consist of a reduced number of studies, however, sufficient enough to define the psychometric properties and its use in clinical practice. *Conclusion*: All the instruments are effective in investigating the motor function in children with cerebral palsy. The GMFM and PEDI are instruments used in worldwide literature; however only one method cannot serve all the groups, leaving the physical therapist responsible for choosing which method is more indicated for the objectives of his patient.

Effects of Mental Practice on Motor Skill Learning

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Aim: To compare the effect of mental training and motor training on the performance of a new motor ability involving sequential movements of opposition of the fingers and to verify the transfer in the learning process with mental practice. *Methods*: This study compared the motor performance of the dominant and non dominant hand through the analysis of speed and precision in two sequences of 5 movements of fingers opposition, one for training (ST) and other not (SC), before, 5 min, 24 hours and 7 days after an only session of training with the dominant hand, 20 min of duration, divided in 4 blocks separated by 5 min of rest, in 20 health participants, 14 women and 6 men, with mean age of 22.5 years ($p = 0.71$). Ten participants did only the mental training of the task (TM) while others did the motor training portion of the task (TR). *Results*: Although both groups had a significant improvement in the motor performance of the ST through the TM ($p = 0.019$) and the TR ($p = 0.0001$), there was a significant difference in the performance after the two forms of training ($p = 0.03$), favoring the TR. After 7 days of training the group that did the mental training showed improvement in the performance ($p = 0.005$) while the group that did the motor training did not. There was a transfer in the learning process with improvement in the motor performance of the non trained hand. *Conclusion*: Mental practice makes possible learning, retention and transfer of a new motor ability although comparing with the same period of motor training provides inferior performance. Thus, mental practice has to be considered as a therapeutic alternative for the improvement of the performance together with motor practice or separately, in cases when motor practice is impossible.

Impact of Home-Exercise Program for Stroke Patients on Functional Performance

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Purpose: The purpose of this study was to verify the effectiveness of a physiotherapeutic program based on fortnightly visits and supported by an illustrated manual of home exercises, in the functional evolution of patients with motor disability after stroke. *Relevance*: The majority of stroke survivors present motor and sensorial alterations which lead to varying degrees of functional limitation. Physiotherapy programs based on weekly supervised care improve functional performance of patients suffering stroke sequelae but represent a long and high-cost process. Home-exercise programs devised specifically for stroke patients are important in that they allow the frequency of visits to the health center to be reduced, thereby cutting costs for both patient and health center. However, further studies are needed to scientifically assess the effectiveness of such programs to justify their inclusion in the process of rehabilitation of such patients. *Participants*: Ninety-three patients with motor disability after stroke (48 males, 45 females, mean age 63 + 8 years), 58 patients were in the acute phase (up to 6 months' evolution after stroke) and 35 patients were chronic (between 7 and 24 months). *Methods*: Acute and chronic patients were

randomly divided into three groups: home exercise group (HEG), supervised care group (SCG), and control group (CG). All groups initially underwent physiotherapeutic and functional assessment using Barthel's index (BI). The HEG received individual fortnightly care, supported by an illustrated manual of home exercises containing three progressive modes of the same movement: assisted-active, free active and resisted-active execution, selected by the physiotherapist according to the patient's clinical progress. The exercises were demonstrated individually on each return visit while progressions in the exercises indicated in the manual were made as the patient evolved. The HEG received individual supervised attention in twice-weekly 45-min sessions, whereas the CG received only general guidance. After 6 months' intervention all patients underwent another functional assessment. *Analysis*: The data obtained was compared using the ANOVA for repeated measurement and the Scheffé post-hoc test. *Results*: According to scores obtained on the BI at initial vs. final assessment, a significant functional improvement was observed in acute HEG (48.25%, $p < 0.0001$) and SCG patients (50.4%, $p < 0.0001$). The same analysis for chronic patients revealed improved functioning only in the HEG (49%, $p < 0.001$). *Conclusions*: The home-exercise program proposed was effective in improving the functional evolution of both acute and chronic stroke patients. At the acute phase, the home exercise program proved as effective as weekly supervised care, whilst at the chronic phase the program was more effective than supervised care. *Implications*: Based on the results of the present study, home exercise programs devised especially to address the motor dysfunctions characteristic of stroke may yield important functional benefits, representing a valid and low-cost tool in the rehabilitation of stroke patients.

Electromyographic Activity of Trunk in Subjects with Post-Stroke Hemiparesis in Different Exercises

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Post-stroke subjects often present motor alterations. Most knowledge about therapeutic approaches is based on lower or upper extremities evaluation, but few studies have investigated the responses of trunk muscles during exercises in patients with hemiparesis. *Objective*: To compare the electrical activity of trunk muscles in subjects with hemiparesis with control subjects during different exercises. *Setting*: Research Laboratory in University Hospital. *Participants*: Twelve subjects with hemiparesis after unilateral stroke, with Modified Ashworth Scale between 1 to 4 points and Barthel scores between 85 to 100 points, mean time after stroke of 11.33 months (standard deviation [SD] = 3.63), mean age 57.58 years (SD = 8.59) and mean body mass index (BMI) 24.70 kg/m^2 (SD = 2.78). The control group was comprised of 12 subjects without neurologic or musculoskeletal dysfunction paired by gender, age, BMI (mean age of 58.75 [SD = 9.72] and mean BMI of 25.13 kg/m^2 [SD = 2.40]). *Interventions*: Trunk flexion exercises (lower extremities elevation in lying down position, lower trunk rotation in lying down position and pelvic retroversion seated in Swiss ball) and extension exercises (upper extremities rising up in seated position, stand up from seated position and pelvic anteversion seated in Swiss ball). *Outcome Measures:* Electromyographic signal in RMS (Root

Mean Square) normalized by maximal voluntary isometric contraction (% MVIC) of rectus abdominis, obliquus externus abdominis and erectus spinae muscles and time of contraction beginning difference(s) between paretic/non paretic side (left/right in control). *Statistical Analysis:* T test was used to compare muscle activation and time of contraction beginning between groups and muscle sides in the same group. To compare different activities, MANOVA was conducted with Tukey post-hoc test to identify group differences. Level of statistical significance was set at 5% ($p \leq 0.05$) *Results*: Rectus abdominis presented higher activation in group with hemiparesis than control group ($p = 0.035$). During lower extremities elevation paretic obliquus externus showed higher activation than others exercises ($p = 0.019$). There was no difference in rectus abdominis and erectus spinae muscle activation between exercises. Erectus spinae did not present significance difference between side and group. Comparing the time of contraction beginning comparison there were no differences between groups. *Conclusion*: Subjects with hemiparesis showed muscle electric activity alterations, mainly the rectus abdominis, in comparison with control. Non paretic obliquos externus was used in a compensatory way during lower extremities elevation.

Comparative Study Between Functional Electric Stimulation (EEF) in Wrist Extensor and Flexor with EEF Only in Wrist Extensor in the Improvement of the Function in Patients with Spastic Hemiparesis Cerebral Palsy

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Cerebral palsy (CP) is a term that qualifies a group of cerebral disturbances due to some injury in the fetal development during the prenatal, perinatal or postnatal periods. These disturbances are characterized by the failure of movement control and by adaptive modifications in muscle length. There is no one method or system that can treat cerebral palsy. Functional electrical stimulation (FES) is a rising resource, a passive medical attendance, not hostile, and painless, showing results in strength gain and motor function. The aim of this study is to verify if FES in wrist extensor and flexor is more effective than applying only on the wrist extensor to improve motor function in patients that suffer from spastic hemiparesis cerebral palsy. *Methods and Materials*: Two patients were split into two different kinds of intervention, patient one (1) was treated by FES in wrist flexors and extensors, patient two (2) passed by the same process but used FES in wrist extensor. *Results*: Patient one and two showed PEDI improvement and Jebsen-Taylor Hand Test improvement. Patient two showed a reduction in wrist extensor spasticity while patient one kept his spasticity unchanged. *Final Appreciation*: In both cases positive aspects has been observed in spasticity and hand function. More studies with a larger number of patients are necessary for a valid and significant result.

Electrical Stimulation in Hemiplegic Patients After Intramuscular Injection of Botulinum Toxin Type A

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Objective: To investigate the effects of electrical stimulation on gait pattern of chronic post stroke hemiplegic patients, who had previously received intramuscular injection of botulinum toxin type A. *Design*: Case reports. *Setting*: A rehabilitation center – Lar Escola São Francisco (São Paulo – SP, Brasil). *Subjects*: Three post stroke hemiplegic subjects with chronic lower limb spasticity, two males and one female, ages 58, 61 and 63, respectively. Subjects had received intramuscular injection of botulinum toxin type A in triceps surae muscles a month before the intervention. *Interventions*: Subjects received electrical stimulation on the motor points of the anterior tibialis muscle during a month, each session lasting 30 min. The equipment used was ENDOMED 582 ID with an intermittent alternating current (Russian stimulation) with the following parameters: Carrier wave frequency of 2500 Hz (medium frequency); burst frequency of 50 Hz; relation burst/interval time of 1:2; ramp up/ramp down of 2 s and amplitude was individualized for each patient (0–100 mA). *Main Outcome Measures*: Assessments were made in the beginning and at the end of the study to evaluate walking speed (m/s), Physiological Cost Index, spasticity (Modified Ashworth Scale) and ankle range of motion with knee at 90º (goniometry). *Results*: Walking speed and ankle range of motion increased in all subjects and Physiological Cost Index and spasticity decreased in two subjects. Thus, the use of electrical stimulation after intramuscular injection of botulinum toxin type A seems to bring improvements in gait pattern of the studied subjects, but a larger study is needed to quantify the treatment effects.

Effect of Different Verbal Instructions for Sit-To-Stand Movement in Chronic Hemiparetic Subjects

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Objective: To investigate the effect of using different verbal instructions for STS movement in chronic hemiparetic subjects. *Methods*: Twelve hemiparetic volunteers (six men and six women) with ages ranging from 65 to 75 years were included in this study. STS movement was assessed using three distinct verbal instructions: "stand-up as fast as you can" (A); "stand-up as fast as you can with your body weight distributed on both legs" (B) and "stand-up as fast as you can with your body weight distributed on your weakest leg" (C). Mean outcome measures were: lower limbs maximum isometric torque; accelerometric measures for investigation of movement time (MT); electromyographic (EMG) activity of tibialis anterior, soleus, quadriceps and hamstring muscles of the affected leg (AL); rising body index (RI) and percentage of asymmetry of Balance Master System. Descriptive statistics and ANOVA were carried out for data analysis with a significance level at $\alpha < 0.05$. *Results*: MT was higher for instruction C (3.02 s ± 0.71) in comparison to other instructions. Men demonstrated a higher peak of maximum activity for quadriceps whereas no differences between instructions were found for other EMG measures. When comparing between genders, RI was similar for both only for instruction C, presenting higher values in men for A and B. When comparing within gender, RI was the same for all instructions in women; for men it was higher

in A (12.97 ± 5.32) than in C (10.91 ± 4.07). For instruction C, 66.7% of subjects tended to distribute their weight mainly on the AL or to decrease the percentage of weight bearing on the nonaffected leg. *Discussions and Conclusions:* Variability of the observed hemiparetic muscle activation patterns and weakness may have contributed to the lack of differences in EMG measures. Higher EMG activity for quadriceps in men could be explained by larger cross-sectional area and higher torque values of these individuals. The higher values found for RI in men for instructions A and B were probably caused by differences in muscle torque between their lower extremities and greater weight bearing values on the AL. RI was higher for the instruction A than for C because men used more of their AL during this last condition. These findings suggest that training STS movement with instruction C may result in better use of the AL as well as reduce MT and give more independence for chronic hemiparetic subjects in this activity.

Influence of the Visual Feedback in the Sagittal Gait of Children with Spastic Diplegic Cerebral Palsy

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The use of mirrors to promote visual feedback in gait training of children with cerebral palsy is extensively applied in physical therapy clinics. However, there are no studies that quantify the influence of this resource in the gait of these children. The purpose of this study is to evaluate, quantitatively, the effect of this feedback. *Methodology*: Data were analyzed for 5 children (age range 5-12 years) with spastic diplegic cerebral palsy, who were in treatment at the Clinic of Physical Therapy in Infant Neurology – HC UNICAMP. Each volunteer was submitted to a cinematic gait analysis. The video shoot was taken in three different conditions: free gait (FG), gait with mirror (M) and gait with mirror followed by verbal command (MC). The videos captured by the video camera were transferred to a computer, edited by the Adobe Premiere Pro 7.0 software and analyzed with the Dgeeme software. Through video editing, the following events that occurred in the right inferior limb, during one gait cycle, were analyzed: the knee flexion at heel strike and swing phase, plantar flexion at heel strike and swing phase and the distance between the base of the fifth metatarsus and the ground during the swing phase. *Results*: The statistical tests applied (one-way ANOVA and Dunnett) did not indicate any statistically significant difference ($p < 0.05$) between the three different gait conditions. However, some data of the M and MC indicated an expressive variation in relation to the FG, such as a decrease in knee flexion, during the heel strike, of 9.7% for M and 13.5% for MC and an increase of it, during swing phase, of 2.5% and 5.6% for M and MC, respectively. In relation of the distance between the base of the fifth metatarsus and the ground during the swing phase, there was an increase of 55.7% for M and 31.7% for MC, when compared to FG. *Discussion*: Although the statistical tests did not indicate difference between the results, there is a clear tendency to alterations in joint amplitude and the distance between the foot and the ground, in the application of visual feedback, with and without verbal command. We associate this absence of significant difference to the formation of the experimental group, which is very heterogeneous. *Conclusion*: Other studies, with a larger and more homogeneous group, are necessary.

Effects of Constraint Induced Movement Therapy in Children with Cerebral Palsy

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Introduction: Among the different types of cerebral palsy (CP), spastic hemiplegia is characterized by the unilateral involvement of upper and lower extremities that can interfere with manual dexterity, contributing to the panorama of sensoriomotor dysfunctions and alterations in hand function. Different approaches are being developed for this population, and the constraint-induced movement therapy (CIMT) has been shown to be one of the most efficacious. This technique involves the restriction of the non-involved upper extremity, combined with an intensive training program of the affected upper extremity. *Aim*: The objective of this study is to evaluate the effects of CIMT in motor function and functionality of children with hemiplegia, compared to children who were submitted to conventional occupational therapy. *Methods*: A randomized clinical trial was performed with 16 hemiplegic children, from 4 to 8 years old. Children were recruited in a Brazilian rehabilitation center and they were randomized in intervention or control groups. The intervention group was submitted to CIMT, with the use of a splint and a sling to restrain the use of the non-affected upper extremity during the day and the intensive training of the affected extremity was performed for 3 hours, during 2 weeks. After this period, the restriction was removed and children were attended with the principles of a functional protocol to improve the performance of relevant activities for each child. Children from the control group maintained their original schedules of occupational therapy. All children were evaluated by a blinded examiner. The instruments used were Jebsen-Taylor Hand Function (JTHF- adapted version) and Pediatric Evaluation of Disability Inventory. Inferential analyses were performed using the ANOVA to evaluate the differences of gains between the intervention and control groups in dependent variables of the study. *Results*: Superior gains were observed in the intervention groups ($p < 0.05$) in the time to perform test 3 and total time of performance of JTHF test and in the scale of caregiver assistance's self-care scale of PEDI. *Conclusion*: The results showed that the intervention led to an increase in speed of the use of the affected extremity and in the functional independence in the intervention group, suggesting that CIMT in association with functional training leads to independence of children in their daily routines.

Functional Implication of Gait After Left or Right-Sided Stroke

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Objective: To quantify and compare parameters of muscle electrical activity and ground reaction force of lower limb during gait in post-stroke patients with left or right side functional involvement. *Method*: Fifteen post-stroke volunteers with left side functional involvement were age, gender and weight matched and compared to 15 post-stroke volunteers with right side functional involvement. Comparison was executed by means of electromyography with four pairs of surface electrodes positioned on the affected side (spastic side), and with a ground reaction force plate. *Results*: There was no statistically significant difference in stride duration ($p = 0.6$),

nor on the analysis of ground reaction vertical forces, weight bearing index, gait velocity, cadence and stride length ($p = 0.53$). *Conclusion*: According to the electromyographic parameters and to the ground reaction force during gait among the post-stroke volunteers with right or left side involvement; we could suggest that functional rehabilitation presented no differences for these individuals.

Electromyographic and Neuromuscular Analysis in Patients with Post-Polio Syndrome

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Proceed to a comparative analysis of the electromyographic (EMG) activity of the muscles rectus femoris, vastus medialis and vastus lateralis, and to assess muscle strength and fatigue after maximal isometric contraction during knee extension. Eighteen patients with post-polio syndrome, age and weight matched, were utilized in this study. The signal acquisition system utilized consisted of three pairs of surface electrodes positioned on the motor point of the analyzed muscles. It was possible to observe with the results of this study a decreased endurance on initial muscle contraction and during contraction after 15 min of the initial maximal voluntary contraction, along with a muscle fatigue that was assessed through linear regression executed with Pearson's test. There were significant differences among the comparative analysis of EMG activity of the muscles rectus femoris, vastus medialis and vastus lateralis after maximal isometric contraction during knee extension. Initial muscle contraction and contraction after a 15 min rest from initial contraction decreased considerably, indicating a decreased endurance on muscle contraction, concluding that a lower limb muscle fatigue was present on the analyzed PPS patients.

Physical Therapy in Cervical Dystonia: A Single Subject Design Study

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Introduction: Cervical dystonia (CD) is the most common type of focal dystonia. It is characterized by involuntary contractions of neck muscles, which results in abnormal movements and postures of head and neck. Physical therapy may have beneficial effects on CD because the "forced" posture associated with abnormal motor performance may provoke limitations in cervical range of motion (CROM) and muscle weakness in neck, shoulder and trunk. Until now, hardly any study has focused on the role of physical therapy effects on CD. *Objective*: To investigate the effects of a physical therapy program consisting of muscle strengthening and CROM exercises in a patient with CD. *Methods*: This was a single subject design study with a 48-year-old CD patient. She had right laterocollis, right torticollis, elevation of the right shoulder and left scoliosis. The physical therapy program consisted of exercises to improve CROM, as well as strengthening and stretching exercises for neck, shoulder and trunk muscles. The patient attended two 50-min sessions three times a week. Assessments were accomplished in four different periods: baseline (before intervention); intervention; immediately after intervention; and follow-up

(eight weeks after intervention). In each period, the patient was evaluated on three different days with a seven-day interval between measures. Mean outcome measures were: CROM measures with cervical range-of-motion device and isometric muscle torque with a Nicholas Manual Muscle Tester hand-held dynamometer. Visual analysis of data was selected for statistical analysis. *Results*: This study includes only the results for CROM and neck muscles' torque. There was a tendency for improvement for CROM of extension and rotation to the right, with maintenance of these values on follow-up. CROM of flexion, left and right lateral flexion and left rotation tended to improve during and after intervention. CROM of retraction showed a clear trend of improvement during the study, returning, however, to basal values on follow-up. The neck's muscle torque also tended to improve throughout and after intervention for all tested muscles. However, throughout follow-up, neck extensors, right and left lateral flexors and left rotators tended to maintain gains obtained at the end of intervention, whereas flexors and right rotators returned to basal values. *Conclusions*: The applied intervention tended to cause benefits on CROM and muscle torque, especially in movements to the left. Findings of the present study suggest that the elected physical therapy program may be a promising method for treatment of CD and, therefore, it should be further investigated.

Influence of Trunk Control on Fine Motor Function of Children with Myelomeningocele

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Introduction: Children with myelomeningocele may present impairments of fine motor functions, even though not being directly determined for the spine injury. Some studies indicate that the trunk instability has a possible relation with this deficit. *Objective*: To determine the influence of trunk control on fine motor function in children with myelomeningocele. *Methods*: Eight children, aged between 6 and 16 years old, participated in the study. Fine motor function was evaluated by the Epilepsi Barn Test (EB-test), and trunk control was measured using the Trunk Impairment Scale (TIS). For statistical analysis, correlations among the variables were calculated using Pearson's test. *Results*: The evaluation of trunk control demonstrated a good performance in most of the children ($n = 6$) and 87.5% ($n = 7$) from the sample presented mild dysfunction in fine motor function. However, a correlation was not observed between the deficit of fine motor function and trunk control ($p = 0.3332$). *Conclusions*: Although studies make evident the correlation between trunk control and fine motor function, other studies must be carried out with a more specific methodology to evaluate trunk control in children with myelomeningocele.

Correlation Between Balance and Walking, Running and Jumping Abilities in Children with Down Syndrome

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Introduction: Children with Down syndrome (DS) present muscle tone and strength reduction, laxity of the ligaments, development delay, mental retardation, as well as other alterations. The association of these factors may result in balance and gross motor function impairments. *Objective*: The purpose was to compare the balance of children with DS and children without neurological impairment, and also correlate balance of children with DS with walking, running and jumping abilities of these children. *Methods*: Twelve children, aged between 4 and 12 years old, participated in the study. For comparison purposes, the sample was divided into two groups: group I (GI) with children recruited from the Down Syndrome Foundation of Campinas, with diagnosis of Down syndrome and acquired ambulation; group II (GII) with children recruited from PRODECAD/UNICAMP, without neurological impairment and matched in gender and age with children from GI. The balance of groups I and II was measured by using the Berg Functional Balance Scale Modified for Children; walking, running and jumping abilities of group I was evaluated using the "D" dimension of Gross Motor Function Measure (GMFM-88). For statistical analysis, the *t*-test was used to evaluate differences between groups and correlations among the variables were calculated using Pearson's test. *Results*: Significant differences in balance were found between children with DS and without neurological impairments ($p < 0.05$), with the score being worse in 100% of children with DS when compared with GII. The walking, running and jumping abilities evaluation of children with DS showed a median score of 85.9% in the "D" dimension of GMFM-88, and correlated positively with balance ($p < 0.05$). *Conclusions*: Even with acquired ambulation, all children with DS presented motor and balance impairments, suggesting the importance of rehabilitation programs until complete motor abilities acquisition.

Effects of AsGa Laser and Stretching on the Serial Sarcomere Number of Injured Skeletal Muscle

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Introduction: Laser irradiation has been extensively used as a therapeutic tool to treat skeletal muscle injuries for enhancing muscle regeneration. Also, it has been previously reported that stretching exercise promotes muscle healing preventing connective tissue proliferation. *Objective*: This study aimed to evaluate the effects of AsGa laser and stretching on injured tibialis anterior (TA) muscle. Left TA was injured by a contusion apparatus. The contralateral TA was the control. Laser therapy was used with 4 J/cm^2 dose for 32 s each, beginning 48 hrs after the lesion, during 7 consecutives days. Stretching protocol consisted of 10 bouts of 1 min each, with 45 s of resting time, initiating on the 8th day, during 3 weeks. Male Wistar rats (weight 349 ± 23 g) were divided in: 1) Control group (CG) ($n = 3$); 2) Lesion group (LG) ($n = 6$); 3) Lesion + Laser group (LLG) ($n = 6$); 4) Lesion + Stretching group (LSG) ($n = 6$); 5) Lesion + laser + stretching group (LLSG) ($n = 6$) and 6) Stretching group (SG) ($n = 6$). After the experiments the animals were weighed, the TAs were excised for evaluation of: muscle weight, muscle length, serial sarcomere number and sarcomere length. *Results*: The results showed a decrease in the final

body weight when compared to the initial in the groups: SG (385 ± 11% vs 356 ± 19%, $p = 0.04$ *t*-test); LLG (367 ± 17% vs 347 ± 19%, $p = 0.002$ *t*-test) and LLSG (367 ± 24% vs 350 ± 34%, $p = 0.02$ *t*-test). The left TA reduced the muscle weight on LG (0.78 ± 0.05 g vs 0.77 ± 0.07 g, $p = 0.01$ *t*-test) while the LLSG showed an increase (0.76 ± 0.09 g vs 0.73 ± 0.03 g, $p = 0.01$, *t*-test). The LLSG presented an increase in left TA length (25 ± 1.87 mm vs 24 ± 1.52 mm, $p = 0.0006$, *t*-test), however there was no difference in the serial sarcomere number. The LG showed an increase of 6% in the serial sarcomere number of left TA (7881 ± 640 vs 7469 ± 327, $p = 0.05$ *t*-test). The sarcomere length increased in LLSG (3.87 ± 0.22 μm) when compared to: SG (3.52 ± 0.15 μm, $p = 0.01$, ANOVA), LG (3.26 ± 0.28 μm, $p = 0.0006$ ANOVA) and LLG (3.31 ± 0.30 μm, $p = 0.001$ ANOVA). *Conclusions*: Probably the stress of manipulation to muscle contusion, laser therapy and stretching, induced the decrease in body weight. The increase in muscle weight observed on injured muscles submitted to laser and stretching suggests hypertrophy, although it was not seen additionally in the serial sarcomere number. The sarcomerogenesis observed in injured muscles could be caused by eccentric stress. The increase of sarcomere length in injured muscles and treated with laser and stretching did not modify the serial sarcomere number. (Financial support: Tuiuti University of Parana and Evangélica Faculty of Paraná)

Balance Training in Chronic Hemiparesis: Effects of Task-Oriented Exercises with Altered Sensory Input

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Deficits after stroke include sensorial, motor and cognitive alterations, and the loss of postural control probably has greater impact on these activities, also in the chronic phase. This research analyzed the effects of balance training with sensorial intervention in chronic hemiparesis. Ten patients with stroke of the Universitarian Hospital of UNICAMP were evaluated before and after the balance training, and one month after the end of the study. We used the Berg Balance Scale (BBS), Functional Independence Measure (FIM) - mobility/transference and locomotion, Dynamic Gait Index (DGI), Fugl-Meyer Protocol (FM), Postural Control and Balance Scale (PCBS), Functional Ambulation Classification (FAC), Postural Assessment Scale for Stroke Patients (PASS) and Activities-Specific Balance Confidence Scale (ABC). We used a training protocol elaborated by the authors with 4 or 5 marks based on the scores of the DGI and PCBS. Each mark represented a group of task-oriented exercises with emphasis on balance training with altered sensory input and the difficulty of the proposed exercises were enhanced, according to the patient´s improvement. These marks were also used to determine the initial state of the disorder and at the tenth session the patients were evaluated again with both scales to analyze the progress on the marks of the training protocol. The training consisted of 20 sessions (two sessions per week) of static and dynamic balance in the following situations: sitting, standing, walking and transference. We used visual tips and visual disturbance, unsteady surfaces and surfaces with different

textures during the task-oriented exercises. We noted an increase of 4.24% ($p < 0.05$) in the BBS after the treatment, the dimension sitting balance of the PCBS rose 7.59% on average and the item stand balance had an increment of 9.72% ($p < 0.05$) on average. The total FM demonstrated an increase of 17.79% ($p < 0.05$). After sensorial intervention, the conscious proprioception had an increment of 13.54%. The task-oriented exercises with altered sensory input improved the functional measures of static and dynamic balance, the perceiver of balance, mobility and it also recovered the proprioception in the chronic hemiparesis.

Unintended Muscle Activity Influences Interlimb Coordination in Locomotion After Stroke

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We show that, in post-stroke hemiplegic survivors, the anomalous muscle coactivation patterns present in the resting paretic limb when the opposite non-paretic limb pedals are present also in the paretic limb during effortful bilateral pedaling. Second, we present a superposition model for the anomalous reaction forces due to anomalous muscle activity during unilateral pedaling and during bilateral pedaling. The results identify muscle activity patterns and functional synergies using principal component analysis. These results use the concept of functional synergies, which in turn may be used to objectively modify intervention strategies of post-stroke locomotion rehabilitation.

Effects of Criotherapy and Stretching in the Sarcomerogenesis of Injured Skeletal Muscle

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Objective: The aim of the present study was to evaluate the effect of criotherapy and intermittent stretching in the treatment of the injured tibialis anterior (TA) muscle. *Material and Methods:* Seventy-three male Wistar rats (weight 342 ± 44 g) were divided into 8 groups: CONTR ($n = 3$): intact control group; CONT ($n = 10$): left TA was submitted to contusion and evaluated 28 days later; CRIO ($n = 10$): left TA was subjected to criotherapy daily, for 7 days; CONT + CRIO ($n = 10$): left TA was injured and treated with criotherapy daily for 7 days; CONT + SAND ($n = 10$): left TA was injured and treated with sand compression every day for 7 days; STRET ($n = 10$): left TA was manually stretched by maximal ankle plantiflexion in a protocol of 10 bouts of 1 min each, 3 times a week for 3 weeks; CONT + STRET ($n = 10$): left TA was injured and stretched 3 times a week for 3 weeks; CONT + CRIO + STRET ($n = 10$): left TA was injured, treated daily with criotherapy for 7 days and stretched 3 times a week for 3 weeks. After the end of each protocol the animals were euthanized for TA excision. The following variables were analyzed: body weight, muscle length, serial sarcomere number and sarcomere length. *Results*: Body weight increased in the groups CONTR (322 ± 6 g vs 241 ± 20 g, $p = 0.02$), CONT+CRIO (364 ± 30 g vs 334 ± 27 g, $p = 6.15E-05$, paired *t*-test) and STRET (385 ± 11 g vs 357 ± 19 g, $p = 0.04$). Muscle length increased in the groups CONT (18 ± 1 mm vs 17 ± 1 mm, $p = 0.02$); CONT + CRIO (23.21 ± 0.86 mm vs 21.05, $p = 0.03$); CONT + SAND (21.92 ± 1.51 mm vs 20.6 ± 1.71

mm, $p = 0.05$). In the CONT group was found an augment in the serial sarcomere number (7881 ± 841 vs 7458 ± 862, $p = 0.05$). In the CONT + CRIO + STRET was observed an increase in the serial sarcomere number (5754 ± 432 vs 5055 ± 290, $p = 0.008$) and a decrease in sarcomere length (3.76 ± 0.20 μm vs 4.08 ± 0.18 μm, $p = 0.02$). *Conclusions*: The muscle contusion induced sarcomerogenesis, perhaps caused by the eccentric stimulus. The association of criotherapy and stretching in injured muscles was sufficient to induce the sarcomerogenesis and probably induced an adaptation in the sarcomere length to the muscle develops its maximal tension. (Financial support: Evangélica Faculty of Parana).

AUTHOR INDEX

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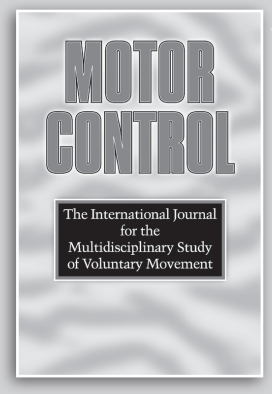

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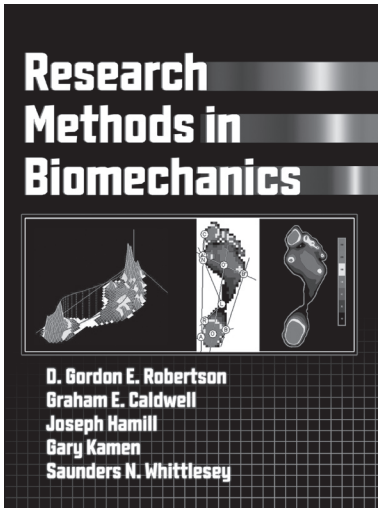

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