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Brief report

The use of a safety harness does not affect body sway during quiet standing

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Abstract

Background. Postural sway during quiet standing reduces when somatosensorial information is provided by an active or passive "light touch" of different body parts with a surface. The contact of the safety harness with the body could induce a similar effect, leading to an undesirable side effect in the balance evaluation.

Methods. This study investigated if a safety harness system, commonly used in balance studies, affects body sway during the balance evaluation. Healthy adults stood as quietly as possible for 60 s in a comfortable position on a force plate. First, we performed an experiment on the light-touch effect with 10 subjects to determine the necessary sample size for the main investigation. Then, 60 subjects completed four tasks where the use of the safety harness and the visual information were manipulated. Area, root-mean square, speed, and frequency of the center of pressure displacement were analyzed.

Findings. A light touch decreased postural sway on both visual conditions but there was no effect of the use of a safety harness on sway when quietly standing, independent of the visual information. Postural sway increased on both somatosensorial conditions when the visual information was not provided.

Interpretation. This result shows that the safety harness does not interfere with the evaluation what is of major importance to methodological aspects of balance evaluation.

Keywords: Balance; Equilibrium; Center of pressure; Light touch; Posturography

1. Introduction

The light touch of different body parts on a surface (applied force <1 N and providing no mechanical support) can provide somatosensorial stimuli useful in reducing postural sway. For example, the light contact with the tip of the index finger on an external surface decreases body sway (Jeka and Lackner, 1994, 1995). The light-touch effect has also been observed during active touch of the head, neck, and shoulder or when the body is passively touched, i.e., when the finger is fixed to an external object by a clamp (Krishnamoorthy et al., 2002; Norrsell et al., 2001; Rogers et al., 2001). Krishnamoorthy et al. (2002) verified the light-touch effect in a variety of tasks independent of the nature of contact (active or passive). However, the effect was more evident when the sensory information was related to trunk orientation (in that case, provided by the head or neck).

Postural control evaluation often uses a safety system consisting of a harness on the body fixed at the shoulders or upper back to the ceiling by cables, which prevents a fall while evaluating the subject. Given the findings about the light-touch effect, it is reasonable to speculate that the contact of the safety system with the body could provide a somatosensorial cue to the

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postural control system to decrease body sway, leading to an undesirable effect on the balance evaluation. Therefore, the purpose of the present study was to verify if the use of a safety harness system affects body sway during quiet standing. Our hypothesis is that the use of the safety harness affects body sway.

2. Methods

The subjects were asked to stand as quietly as possible for 60 s in each trial, with the feet close together on a force plate (OR6-WP-2000, AMTI, Watertown, USA). We recorded the forces and moments at a sampling frequency of 100 Hz and we analyzed the center of pressure (CoP) displacement in the anterior–posterior (AP) and medial–lateral (ML) directions. In addition to the somatosensorial information, we also manipulated the visual information in the experimental trials. The rationale is that the elimination of the visual information challenges the posture control system and accentuates the need for other sensorial information, increasing a possible effect of the safety harness if there is one. Likewise, the subjects' small bases of support, defined by the feet close together, also challenged the postural control system and increased the subjects' instability, particularly in the ML direction.

First we performed an experiment concerning the light-touch effect, where two somatosensorial conditions (with and without light touch) and two visual conditions (with and without vision) were manipulated. In this experiment, 10 healthy adults with mean age 29 years (SD 8), mean height 1.77 m (SD 0.06), and mean weight 74 kg (SD 10) executed the four trials. The order of conditions was balanced across subjects. In the conditions with eyes open, subjects looked at a fixed point located 3 m ahead at eye level. In the conditions with a light touch, subjects rested the index finger of the right hand on a small bar parallel to the floor (applied force <1 N). If the applied force exceeded 1 N, the bar moved down and the subject repeated the trial. The area of the CoP displacement was analyzed and the results (described later) were used to determine the desired effect size we want to be able to detect and the adequate sample size for the next experiment by employing a statistical power analysis.

In the second experiment, 60 healthy adults with mean age: 26 years (SD 6), mean height: 1.72 m (SD 0.10), and mean weight: 69 kg (SD 12) executed four tasks where two somatosensorial conditions (with and without the safety harness) were crossed with two visual conditions (with and without vision). The order of these conditions was also balanced across subjects. Again, in the conditions with the eyes open, subjects looked at a fixed point located 3 m ahead at eye level. In the conditions with the safety harness, we used a commercial safety harness for working at heights (Newton, Petzel) anchored to the laboratory ceiling at the subject's shoulders by flexible cables. The safety harness did not limit the body sway, nor did it provide mechanical support to the body; it just prevented a fall. We use this safety harness in studies about postural control in our laboratory; it is similar to other safety harnesses commonly used in balance tests. None of the subjects had prior experience with the use of a safety harness during standing. The subjects participated voluntarily in the two experiments and they gave informed consent prior to the experiments, according to the procedures approved by the Internal Review Board of the University of São Paulo.

The data analyses were performed in Matlab 6.5 software. The CoP data were low-pass filtered at 30 Hz with a Butterworth filter. After filtering, the first 10 s of the trial, considered as an adaptation period, were removed and the data were demeaned. For the remaining 50 s CoP data, we computed the area of the CoP sway and for each direction, we computed the root-mean square (RMS), mean speed, and frequency of the CoP data. The CoP area was estimated by fitting an ellipse to the CoP data (AP versus ML) that encompasses 95% of the data (using the method given in (Duarte and Zatsiorsky, 2002) but with the axes length multiplied by 2.45 instead of 1.96). The CoP speed was calculated as the total CoP displacement divided by the total period. The frequency of the CoP displacement is the frequency at which 80% of the CoP spectral power is below (for details, see Baratto et al., 2002). The power spectral density of the detrended CoP data was estimated by the Welch periodogram method with a resolution of 0.039 Hz.

The effects of the different somatosensorial conditions in the two visual conditions were determined using two-tailed *t*-tests for paired samples with an alpha level of 0.05 using the SPSS 10.0 software. A statistical power analysis was performed utilizing the GPOWER software (Erdfelder et al., 1996) and a two-tailed *t*-test for paired samples with an alpha of 0.05 and a statistical power of 0.8.

3. Results

The first experiment with 10 subjects showed that a light touch reduced the CoP area with open eyes (no light touch: 5.3 cm^2 (SD 2.5), light touch: 3.6 cm^2 (SD 2.1); $P = 0.03$) as well as with closed eyes (no light touch: 5.5 cm^2 (SD 2.6), light touch: 3.1 cm^2 (SD 1.3), $P = 0.009$). We considered that mean differences of at least half of the mean differences observed for the weakest effect of the light touch would be important to investigate the effect of the safety harness. Therefore, considering a difference of 0.85 cm^2 (half of the difference for the conditions with vision), the within-conditions standard deviation, and the use of a paired t-test, we obtained an effect size of 0.38 (Erdfelder et al., 1996). Then, for a desired power of 0.8 and alpha of 0.05, a sample of 57 subjects was necessary. In the present experiment, we analyzed 60 subjects. With such a sample size we have an 80% probability of detecting a difference as small as 0.85 cm^2 (half of the difference that would be observed for the light-touch effect) between the conditions with and without the safety harness.

In the second experiment, no effect of the safety harness on the CoP sway in any direction was observed independently of the visual information: see Table 1 and Fig. 1. It is of note that all variables of CoP sway in the conditions with vision, presented lower values than in the conditions with no vision, with the exception of the variable RMS in the AP direction for the condition with harness: see Table 1 and Fig. 1.

4. Discussion

The purpose of this study was to examine whether the use of a safety harness affects body sway during quiet standing. Such an effect has been observed when different body parts lightly touch a surface or when the body is touched by an external object (Jeka and Lackner, 1994; Krishnamoorthy et al., 2002; Norrsell et al., 2001; Rogers et al., 2001).

Our first experiment indeed confirmed the effect of the light touch in reducing body sway in both visual conditions, as observed in previous studies. However, we did not observe any effect of the safety harness on the body sway measured by the variables area, RMS, speed, and frequency of CoP sway during quiet standing with or without visual information. Note that a task similar to quiet standing with a safety harness has been studied before and showed a reduction in body sway (Krishnamoorthy et al., 2002). Krishnamoorthy et al. (2002) reported that a passive touch to the head or neck by a fixed reference point was more effective in reducing body sway than a finger touch. They also observed a reduction in body sway while the subject held a 30 N load externally suspended by a pulley system, evidencing that an external reference with small inertia could be sufficient to decrease body sway. Note that the light-touch effect has also been observed in another experiment with a non-fixed object: Riley et al. (1999) observed a decrease in posture sway when the subjects were asked to keep the fingers fixed on a cloth curtain suspended from the ceiling. Our results indicate that the safety harness used here, more precisely the flexible cables that attached the harness to the laboratory's ceiling, did not provide an external fixed reference point on the shoulders or did not have sufficient inertia to be used as a source of somatosensorial information to reduce body sway.

Table 1
P-Values for two-tailed paired t-tests for the variables area, RMS, speed, and frequency of the CoP sway in the anterior–posterior (AP) and medial–lateral (ML) directions for the somatosensorial and visual effects

Effect	Area	RMS		Speed		Frequency	
		AP	ML	AP	ML	AP	ML
With harness							
With vision	0.80	0.25	0.88	0.56	0.88	0.32	0.44
No vision	0.74	0.84	0.71	0.82	0.69	0.58	0.69
With vision							
With harness	0.02	0.17	0.04	<0.005	<0.005	<0.005	<0.005
No harness	0.01	0.03	0.03	<0.005	<0.005	0.03	<0.005

$n = 60$.

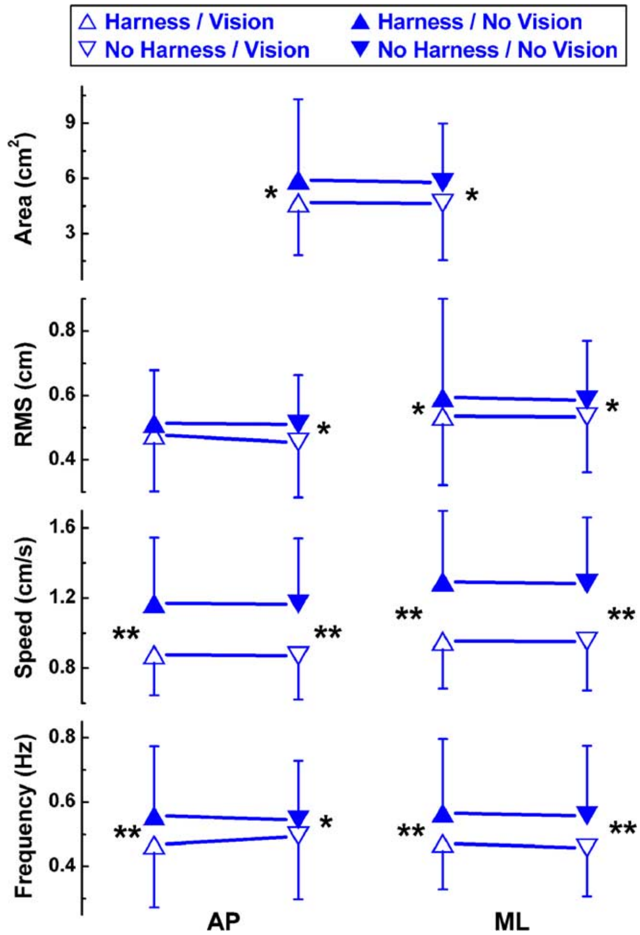

Fig. 1. Mean and standard deviation of the variables area, RMS, speed, and frequency of the CoP sway in the anterior–posterior (AP) and medial–lateral (ML) directions for the somatosensorial conditions (harness vs. no harness) and the two visual conditions (vision vs. no vision). $*p < 0.05$; $**p < 0.005$. Note that all significant effects are due to the manipulation of visual information. $n = 60$.

Due to the small inertia of the flexible cables, the movement of safety harness was coupled to body during quiet standing. However, this does not mean that the safety harness provided information (or that the postural control system used this information) that was sway-referenced (sensory information coupled to the body sway, which provides erroneous signals to the posture control system, see for example Peterka, 2002). In such a case, it has been shown that the body sway increases when sway-referenced light-touch information is provided to the subjects due to a conflict of sensory information that confounds the postural control system (Reginella et al., 1999). However, we did not observe such a phenomenon here. We believe that no information related to body position was provided by or used from the safety harness during quiet standing. In view of that, although we investigated balance only in a static condition, we think that in experiments with support surface sway-referencing or visual surround sway-referencing, where the use of a safety harness device is very common, body sway will also not be affected by such device.

In summary, the use of the safety harness did not affect the posture sway in quiet standing independently of the visual information. Of course, we used a safety harness that did not limit the subject's movement and our results apply only to this situation. In addition, our results are limited to healthy adults and it is possible that an effect of the use of a safety harness could be observed in individuals with a balance deficit during challenging postural tasks, but, most probably, such effects would be due to the psychological impression of safety provided by this device.

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