Quantitative Assessment of Postural Alignment in Young Adults Based on Photographs of Anterior, Posterior, and Lateral Views

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Abstract

Objective: Postural assessment through photography is a simple method that allows the acquisition of quantitative values to define the alignment of body segments. The purpose of this study was to quantitatively assess the postural alignment of several body segments in standing through anterior, posterior, and lateral views.

Methods: In this cross-sectional study, 122 subjects were initially evaluated. Seven subjects were excluded from the study after cluster analysis. The final sample had 115 subjects, 75% women with a mean age of 26 ± 7 years. Photographs were taken from anterior, posterior, and lateral views after placement of markers on specific anatomical points. Photographs were analyzed using free Postural Analysis Software/Software of Postural Analysis (PAS/SAPO). Quantitative values for postural analysis variables were ascertained for head, upper and lower limbs, and trunk, along with the frequency of inclinations to the left and to the right.

Results: Regarding the head, 88% of the sample presented some inclination, 67% of which was to the right. There was a predominance of right inclination of the shoulder and pelvis in 68% and 43% of study subjects, respectively. Lower limbs presented mean alignment of 178° in the anterior view, and the trunk showed predominant right inclination in 66% of participants.

Conclusion: Small asymmetries were observed in anterior and posterior views. This study suggests that there is no symmetry in postural alignment and that small asymmetries represent the normative standard for posture in standing. (J Manipulative Physiol Ther 2011;34:371-380)

Key Indexing Terms: *Posture; Physical Therapy (Speciality); Technology Assessment; Biomedical; Phothographs*

Posture may be described as the composition of the positioning of all body segments at a given point in time.[1] Correct static posture is considered an important marker of health.[2] Postural assessment is essential for research and manual therapy diagnostics, to verify and compare the efficiency of interventions. Photography has been used by manual therapists as a method of recording postural analysis. Several factors are important to ensure the reliability of studies based on photograph analysis, including palpation of bone anatomical points for marker placement and reproducibility of the photo digitalization process.[2-5]

Empirical observation reveals that the ideally aligned symmetric reference pattern proposed by Kendall et al[6] is subjective and not predominant in the population at large, despite having been adopted as the international baseline for normal posture.[7] Review of this model has been a cause for concern among researchers,[8,9] but studies conducted to date have assessed only 1 or 2 body segments on a single

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view, hampering any meaningful discussion on overall postural alignment.[3,8,10-13]

The technological tools currently available allow quantitative analyses of posture based on photographs, but the available articles, however, do not analyze global body posture. The simultaneous assessment of all body segments enables the proposal of a coherent postural model and can pave the way for future valuable clinical discussions on postural alterations and musculoskeletal lesions. The study of global posture in healthy subjects, as the one presented in this report, is essential for the establishment of reference values for normal postural alignment. The use of quantitative assessment is very important for physical therapy appraisal, but it should be complementary to the qualitative physiotherapy analysis.

Distinctive features of the Postural Analysis Software/Software of Postural Analysis (PAS/SAPO), when compared with other available software, include the global body posture analysis and the analysis of angles and distances independently. This software was developed specifically for photograph analysis applied for health purposes and permits the archiving and comparison of photographs to observe the evolution of the patient. The software also permits calibration and photo adjustments to prevent small measurement errors and increase the reliability of the method.

The aim of the present study was to quantitatively assess the positioning of several body segments in the upright standing posture of young healthy adults through anterior, posterior, left lateral, and right lateral views.

Materials and Methods

A total of 128 subjects were initially assessed, 6 of whom were excluded for presenting a diagnosis of orthopedic lesion. The remaining 122 study participants underwent cluster analysis[14] for similarity of study variables, which yielded a group cluster of 115 subjects that comprised the study group. The project (758/02) was approved by the ethics committee of Hospital das Clínicas, School of Medicine, University of São Paulo. All participants signed the free and informed term of consent. Data collection was carried out at the Biophysics Laboratory of the School of Physical Education and Sports of São Paulo University.

Posture was assessed using 2 digital Sony Cybershot cameras (Sony, Japan), model P92 and P93A; 2 tripods; 15-mm polystyrene balls, double-sided adhesive tape; a rubber mat measuring 70 × 74 cm; white chalk; 2 plumb lines marked with 4 polystyrene balls; an interview protocol; and a software for postural analysis (PAS/SAPO), developed in conjunction with this study. The cameras were mounted on 63-cm-high tripods and placed perpendicular to each other allowing 2 shots at a time to be taken (anterior and right lateral, posterior and left lateral). The first camera was placed 195 cm away from the subject to be photographed, whereas the second was placed at a distance of 252 cm. For photo calibration purposes, 2 plumb lines were affixed to the ceiling, marked with 4 polystyrene balls with a distance of 0.80 m between each.

The procedure was performed always by the same physiotherapist. It consisted of filling out a protocol interview, affixing of small polystyrene balls to the skin at predefined anatomical points using double-sided adhesive tape, taking photographs of anterior, posterior, and left and right lateral views, and analyzing photos using the postural analysis software (PAS/SAPO).

The 50 anatomical points marked were as follows: ear lobe, glabella, menton, sternum manubrium of sternum, acromion, lateral epicondyle, midpoint between the radial styloid process and head of the ulna, styloid process of the radial, anterior-superior iliac spine (ASIS) and posterior-superior iliac spine (PSIS), greater trochanter of femur, knee joint line, tibial tuberosity, lateral and medial maleoli, calcaneus, point between the second and third metatarsal heads, inferior angle of the scapula, transition point between the medial border and scapula spine and the spinous processes of C7, T1, T2, T3, T5, T6, T7, T9, T11, T12, L1, L3, L4, L5 and S1. Of these 50 points, 16 were bilateral. Groups of 3 polystyrene spheres superimposed were placed on each vertebra to provide visualization on lateral views. Blackened spheres were placed at the transition of the scapula spine with the medial border of the scapula and at the inferior angle of the scapula, to prevent these points from being confounded with the spinal column markers on lateral views.

The 4 photographs were taken while the subject was standing on the rubber mat. To ensure the same foot positions for all 4 photographs, the subject was instructed to position themselves on the mat while an outline was drawn around their feet using chalk. After the simultaneous photographing of anterior and right lateral views, the mat was rotated 180° from the initial position for photographing the posterior and left lateral views, and the subject was instructed to place their feet on the marked out regions. Marks on the floor were made so that the mat would always be placed in the same place.

Photograph analysis was performed using free open-source PAS/SAPO, which determined coordinates of the anatomical points on the photographs. PAS/SAPO was developed by a multidisciplinary team together with this study and is available at http://sapo.incubadora.fapesp.br, and includes scientific tutorials as well as several resources to support the analysis of photographs. PAS/SAPO was submitted to an assessment of interrater and intrarater reliabilities.[15]

Data were submitted to descriptive statistical analysis. Quantitative values for head, upper and lower members, and trunk alignment were obtained, along with the frequency of inclinations to the left and to the right.

The measurements used for posture analysis included distances (in centimeters) and angles (in degrees), taken from the combination of anatomical points outlined in Table 1.

Table 1. *Postural analysis variables and the anatomical points used to determine them*

Variables	Anatomical points used in measurements
Anterior view	
Distance between medial malleoli	Distance between the 2 medial malleolus
Inclination of the head	Angle between glabella, menton, and a horizontal line
Horizontal alignment of the head	Angle between the 2 ear lobes and a horizontal line
Horizontal alignment of the acromions	Angle between the 2 acromions and a horizontal line
Horizontal alignment of the ASISs	Angle between the 2 ASISs and a horizontal line
Anterior alignment of the right lower limb	Angle between the large trochanter of the right femur, the articular line of the right knee, and the right lateral malleolus
Anterior alignment of the left lower limb	Angle between the large trochanter of the left femur, the articular line of the left knee, and the left lateral malleolus
Angle between the 2 acromions and the 2 ASISs	Angle between the 2 acromions and the ASISs
Lateral views	
Horizontal alignment of the head	Angle between the C7 spinal process, the ear lobe, and a horizontal line
Horizontal alignment of the pelvis	Angle between the ASIS, the PSIS, and a horizontal line
Sagittal alignment of the lower limb	Angle between the large trochanter of the femur, the articular line of the knee, and the lateral malleolus
Angle of the hip joint	Angle between the ASIS, the large trochanter of the femur, and the articular line of the knee
Angle of the ankle	Angle between the lateral malleolus, the articular line of the knee, and a horizontal line
Vertical alignment of the torso	Angle between the acromion, the large trochanter of the femur, and a vertical line
Vertical alignment of the body	Angle between the acromion, the lateral malleolus, and a vertical line
Alignment of the upper limbs	Angle between the acromion, the lateral epicondyle, and the point between the radius and the ulna
Sagittal alignment of the body	Angle between the acromion, the large trochanter of the femur, and the lateral malleolus
Angle of the thoracic kyphosis	Measure proposed by Leroux et al, 2000
Angle of the lumbar lordosis	Measure proposed by Leroux et al, 2000
Posterior view	
Alignment of the scapulas related to T3	Difference of the distances of the scapulas to the T3 vertebrae
Scapular alignment	Angle between the point of intersection of the spine of the scapula and the medial margin, the inferior angle of the scapula, and a horizontal line
Horizontal alignment of the PSISs	Angle between the 2 PSISs and a horizontal line
Horizontal alignment of the scapulas	Angle between the inferior angles of the scapulas and a horizontal line

The distances were measured in centimeters, and the angles, in degrees.

The criteria used to determine the variables for postural analysis were the anatomical and biomechanical characteristics of each segment and joint.

For each subject, 4 photos were analyzed (anterior, posterior, and left and right views). The analysis was conducted according to the following procedure: opening of the photo, 40% zoom, image calibration using the plumb line, marking of anatomical points, and producing of a report on the placement of the points in terms of x (horizontal) and y (vertical) coordinates.

All of the variables underwent cluster analysis, and because the left and right side views showed no appreciable difference, we decided to use the mean values of the 2 views for the following: trunk and body inclination in the anterior-posterior direction, position of the pelvis, hip, knee, and ankle joints. For variables pertaining to the position of the upper member and the head, the lesser value found of the 2 sides was used.

The study of postural alignment on anterior and posterior views encompassed 23 variables. The inclinations to the right and to the left were expressed by signs, where the mathematical standard was adopted, using positive values in the anticlockwise direction and negative in the clockwise direction.

Figures 1, 2, and 3 illustrate the schematic representation of the angles measured in each view.

Data Analysis

Cluster analysis was performed to identify and exclude individuals who showed considerable discrepancies arising from any errors in the evaluation of the photo or transcription of the values and thereby obtain a homogeneous sample that would allow the discussion of average values for the studied variables. The sample was reduced to 115 subjects for the analysis of the results.

The variables of postural assessment were analyzed by mean, standard deviation, and maximum and minimum values.

For alignment of the head in relation to the trunk, 90° was considered the baseline value. The zero value was considered ideal positioning for the horizontal alignment of the head, shoulders (between acromial), pelvis

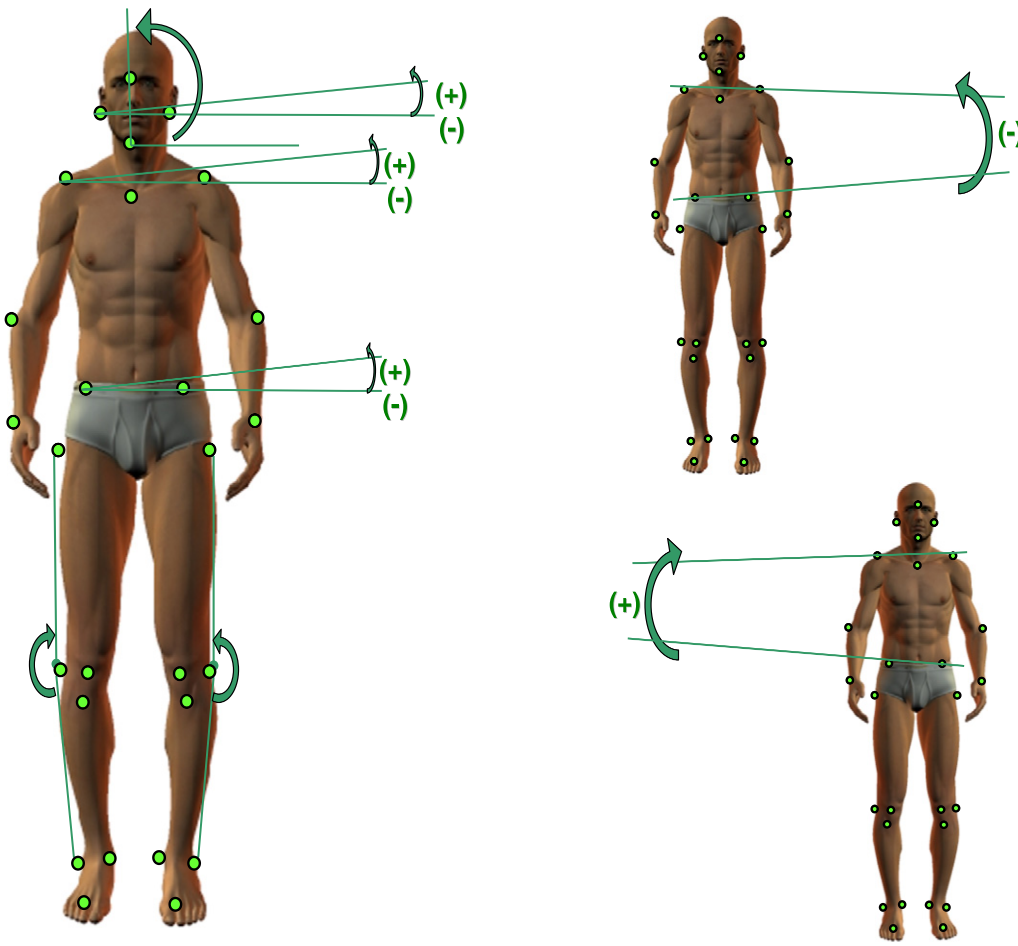

Fig 1. *Anatomical points and angles assessed in the anterior view. The positive sign indicates inclination to the right and the negative sign indicates indication to the left.*

(ASISs), and torso (angle formed between acromial and ASISs), all of them in anterior view. In the lateral view, with the exception of the angles of kyphosis and lordosis, no baseline reference values were defined for the other variables because they were not found in the literature. Zero was considered a symmetric alignment of the right and left scapula in relation to T3 in the posterior view.

Results

Demographic data indicate a mean age of 26 ± 6.90 years, 75% women, 73% with normal body mass index (BMI), and 92% right handed (Table 2).

Table 3 describes the variables of the anterior view. Several standard baseline reference values were defined in this study for assessing postural alignment. The inclination of the head showed an average close to the reference value and a range from 7° to the right or to the left, with predominance to the right. An asymmetry was observed in the alignment of acromial, ASISs, and the angle between the acromial and ASISs, and there was a predominance of a small inclination to the right. The lower limbs showed similar alignment.

The position of the head, torso, and upper and lower limbs in lateral views are shown in Table 4. Measures involving the hip, ankle, kyphosis, and lordosis showed greater variability.

Table 5 shows the variables from the posterior view, showing slight asymmetry in the positioning of the scapula and the pelvis tilt, predominantly to the right.

Discussion

The aim of the present study was to perform a quantitative overall assessment of the postural alignment of young healthy adults in standing, based on anterior, posterior, and lateral views. To the best of our knowledge, this is the first study involving a sample of 115 individuals submitted to the analysis of several body segments through different views, as opposed to only 1 or 2 segments analyzed using one singular view. Moreover, the present study was conducted in line with the trends in the scientific literature[5] using the regional interdepen-

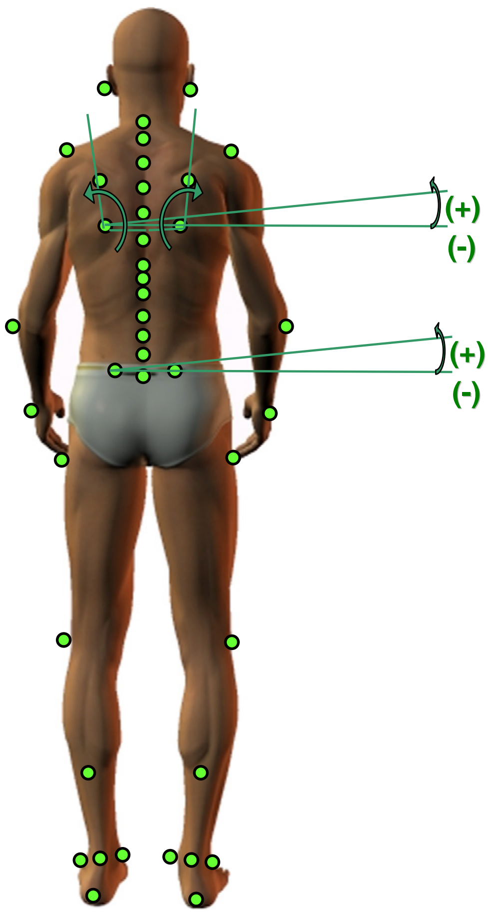

Fig 2. *Anatomical points and angles assessed in the posterior view. The positive sign indicates inclination to the left and the negative sign indicates inclination to the right.*

dence model for the musculoskeletal examination and in physiotherapeutic treatment.[16]

There are small variations in the alignment of body segments in the anterior and posterior views in healthy subjects.

There is no standard approach to evaluate posture.[2] Methodologies used in the study of postural alignments vary,[5] and studies usually assess a single segment, such as the position of the head and shoulder,[13] curvature and length of thoracic kyphosis and lumbar lordosis,[11,17] cervical spine,[12] position of the head and shoulder in sagittal plane,[18] and alignment of the spine and pelvis in lateral view,[10] hampering any comparison of results. Generally, these studies describe the mean values of angles found for each of the segments, but with different methodologies. The comparison of the studies available is also limited by the small sample sizes or different methods used, thus stimulating further studies.[13]

In the present study, it was not possible to identify a standard for symmetric postural alignment along the lines of that proposed by Kendall et al.[6] This standard has been called into question by several authors,[8,9] who noted that the ideal posture may not be a normal posture and that guidelines proposed by Kendall et al[6] used as a baseline reference in physiotherapy schools should be reviewed. These authors suggested that future studies address other body segments and involve a larger sample of subjects without history of musculoskeletal problems, thereby contributing to the debate over a baseline reference standard for posture.

The current study assessed the head on a sagittal plane using the angle formed between C7–ear lobe–horizontal line. Some authors have used the angle formed between the tragus-C7-horizontal line,[8,12,19] but in spite of the fact that anatomical points were not exactly the same, the values were similar. Concerning horizontal alignment of the head on the frontal plane, the value expected and indicative of symmetry was zero, corresponding to 180° alignment. The average value obtained was 1.5°, differing to the study by Raine and Twomey,[13] which also assessed alignment between the ear lobes and the horizontal line but found a mean value of 0.1°. The present study also assessed head inclination on the frontal plane and considered an expected value of 90°, but the data showed a mean value with difference of 7° to the right or left inclination, with predominantly right inclination of the head in 64% of the sample. This can be interpreted as a variation of head positioning in healthy subjects.

Some studies carry out assessments with the subject in a seated position,[20] whereas others use qualitative descriptors to characterize the position of the head or concentrate on the correlation between the posture and clinical findings. In this context, studies to quantify these postural variations are needed.[13]

A value of zero for horizontal alignment indicates symmetry. The mean value measured in our study was 1.31°. Raine and Twomey[13] measured the alignment between the coracoid processes and detected an average value of 1.2°. These authors highlighted that this indicated that the right shoulder had an alignment of 1° lower than the left shoulder. This agrees with the data in this study, in which it was observed that the right shoulder was lower than the left shoulder showing an inclination to the right in 68% of the sample. The use of the acromions in the present study was decided because they are a structure visible on both the anterior and the lateral views.

The comparison of data concerning the pelvis with other studies is difficult because most of the articles have described the position of the pelvis based on radiographic analysis and have assessed measurements such as the incidence of pelvis tilt but have not used measurements obtained from postural assessment or clinical experiences in evaluating posture.[21-24] Some authors used anthropometric measurements to assess the sacroiliac joint but analyzed the position of one iliac in relation to the other based on anterior or posterior rotation and did not report the value for iliac spines alignment. The evaluation of the pelvis in the present study used anterior, posterior, and lateral views based on the

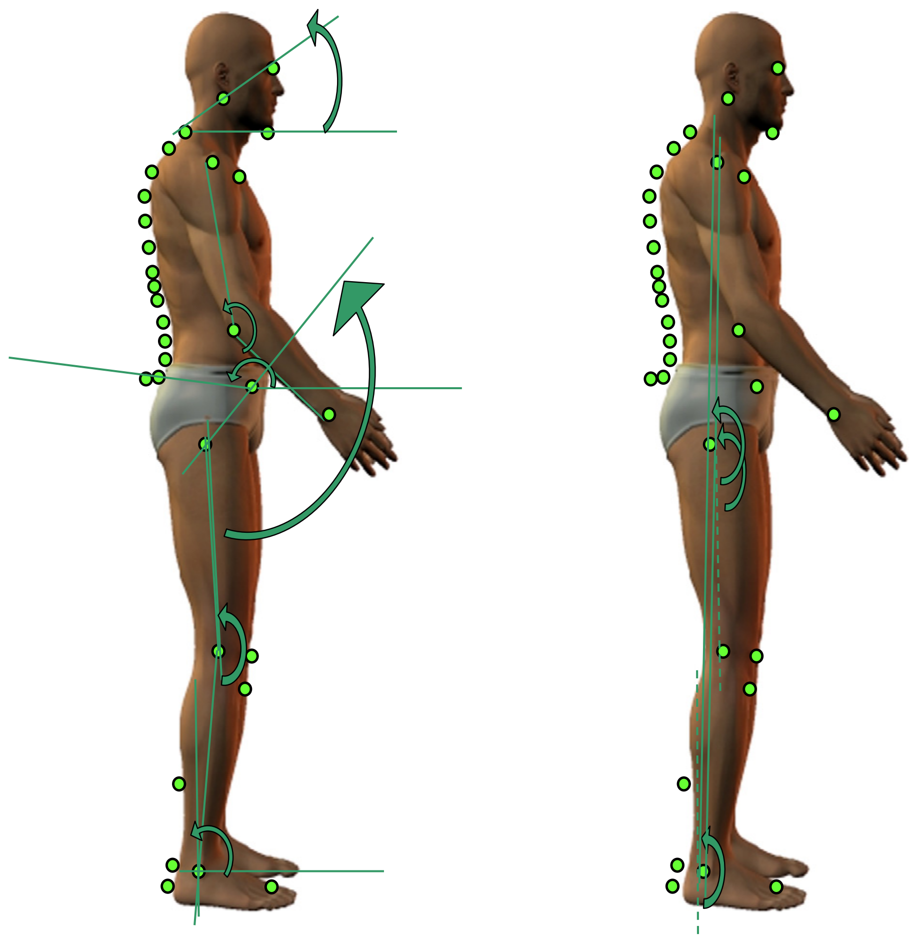

Fig 3. *Anatomical points and angles assessed in the lateral views.*

Table 2. *Distribution of the demographic variables: age, sex, BMI and dominant limb (n = 115)*

Variables		
Age (y), mean ± SD	26 ± 6.90	
Sex	n	%
Female	86	75
Male	29	25
BMI (kg/cm^2)		
Low weight	11	10
Normal weight	83	73
Overweight	19	16
Obesity	1	1
Dominant limb		
Right	106	92
Left	9	8

alignment between the ASISs in anterior view, PSISs in posterior view, and between both in lateral view. Pelvis alignment on anterior and posterior views presented predominant inclination to the right. The variation to the left and to the right indicated by minimum and maximum values in anterior views was approximately 4°. However, 4° of tilt of the pelvis was the highest value found in the sample, and the average value of the sample, which was used for the discussion, was of only 0.2°. In this case, results can be interpreted independently from the position of shoulders and head because the inclinations are very small and allow this simplification. Had the amplitude of those inclinations been higher than the slopes of the pelvis, shoulders and head would be more interdependent, and further analysis would be required. The relationship between ASISs/PSISs on lateral views indicated variability from 158° to 182°.

Levangie,[25] in a study on the association between pelvic asymmetry and lumbar pain, investigated the symmetry between the ASISs/PSISs to ascertain the absolute difference in millimeters and classified the results into 4 categories producing an index for describing pelvic asymmetry, translated as torsion among the iliacs. However, no comparison was possible with our data because our assessment was based on pelvic position in degrees in 3 views.

The average value obtained for anterior alignment of the right and of the left lower limbs presented no difference. This was to be expected because the sample consisted of

Table 3. *Mean (SDs), minimum and maximum values, and percentage of right and left inclination for the variables of posture observed in anterior view (n = 115)*

Variables	Mean (SD)	Value (min/max)	Tilt (%)	
			R	L
Distance between the 2 medial malleoli	7.4 (3.1)	1.5/14.0	–	–
Head inclination (0°-90°)	91.3 (2.5)	82.8/97.0	64	36
Horizontal alignment of the head	1.5 (2.4)	−5.4/9.6	67	21
Horizontal alignment of the acromions	1.3 (2.0)	−3.5/7.0	68	23
Horizontal alignment of the ASISs	0.2 (1.6)	−4.4/4.3	43	36
Anterior alignment of the right lower limb	178.1 (3.4)	171.0/189.0	–	–
Anterior alignment of the left lower limb	178.1 (3.8)	167.7/187.9	–	–
Angle between the 2 acromions and the ASISs	1.1 (2.4)	−5.3/6.9	66	33

The positive sign indicates inclination to the right and the negative sign indicates inclination to the left. The distance between the 2 medial malleolus is given in centimeters, all the other measures are angles given in degrees.

Table 4. *Mean (SD) and minimum and maximum values for the postural variables observed in the lateral views, measured in angles, expressed in degrees*

Variables (deg)	Mean (SD)	Minimum	Maximum
Horizontal alignment of the head	47.1 (4.8)	31.2	58.4
Horizontal alignment of the pelvis	172.6 (4.8)	158.6	182.4
Sagittal alignment of the lower limb	177.9 (4.8)	166.7	190.6
Hip joint angle	149.8 (8.0)	129.7	176.2
Ankle joint angle	86.2 (2.6)	79.9	91.6
Vertical alignment of the torso	182.4 (2.1)	177.6	187.0
Vertical alignment of the body	178.2 (0.9)	175.8	180.0
Upper limb alignment	155.8 (5.1)	145.7	170.7
Sagittal alignment of the body	186.8 (3.6)	176.4	198.5
Thoracic kyphosis angle	55.4 (7.4)	39.3	68.2
Lumbar lordosis angle	47.7 (15.4)	23.3	96.4

healthy subjects. The study of Nguyen et al[26] observed no difference between the right and the left lower limbs but saw a difference between the sexes in which women presented greater mean values for pelvic tilt, hip anteversion, quadriceps angle, tibiofemoral angle, and genu recurvatum. Our sample consisted of 75% women, thus preventing comparison between sexes.

The method proposed by Leroux et al[11] was used for anthropometric analysis of the curvature of the thoracic kyphosis and lumbar lordosis. The thoracic kyphosis and lumbar lordosis are well described based on radiologic measurements,[10,12,22,23,27] but not as well analyzed based on anthropometric measurements. Dunk et al[28] proposed the calculation of the angle of curvature in lumbar lordosis, thoracic kyphosis, and cervical lordosis by using markers placed at L5, T12, and C7. The average found in the present study for thoracic kyphosis was 55.4°, and for lumbar lordosis, it was 47.7°, vs means reported by Leroux et al[11] of 36° and 51°, respectively. This method of assessment of the spine is particularly vulnerable because it depends on the placement of markers on the specific anatomical points as well as on the type of marker used. Small polystyrene spheres were used as markers in this study, but because they are not visible on side views because of the scapula, 2 or 3 spheres were placed on top of each other to increase visibility, which may have increased the error associated with measurements. Hinman,[29] in his study comparing thoracic kyphosis and postural stiffness in young and elderly women, used a flexometer and observed that the chances of measurement error were significant because of the use of the instrument or to the localization of the vertebrae. To implement the methodology proposed by Leroux et al[11] without restrictions, a marker should be devised, which does not compromise the measurement. Studies should be conducted to discuss a possible methodology for assessing the vertebral column valuing the 3-dimensional aspects of the region.

The study of postural alignment assumes the inclusion of several body segments that, in turn, generate a large number of variables. In this study, the criteria established were to prioritize measurements in angles rather than in distances because anthropometric differences may compromise results when these are presented in centimeters. Because photograph analysis was used, only 1 plane was considered, but associated rotations may also be present, which may impact reliability of measures obtained from distances. The measurement of angles can be considered reliable even for situations in which the points analyzed are not on the same plane.

No reliable foundation exists on which to base decisions regarding normality or abnormality or on progressive improvement or worsening of posture.[30] It is clear that the localization of anatomical points may be subject to errors and that some measures are susceptible to errors caused by anthropometric characteristics and assessment method. Despite these limitations, the establishing of quantitative measures can provide a basis for comparing postural assessment in a less subjective and personal manner. Quantitative assessment of postural alignment is important for clinical practice because it enables the measuring of load distribution and mechanical demands on musculoskeletal structures.

Table 5. *Mean (SD) and minimum and maximum values for the postural variables observed in the posterior view (n = 115)*

Variables	Mean (SD)	Value (min/max)	Tilt (%)	
			Right	Left
Alignment of the scapulas related to T3—the difference of the distance from scapula to T3 (cm)	0.5 (1.1)	−1.6/4.2	–	–
Angle between the intersection point of the scapular spine and the medial margin of the scapula, the inferior angle and a horizontal line (deg)	6.6 (4.8)	0−21.8	–	–
Horizontal alignment of the scapulas (deg)	−0.4 (4.3)	−15.0/11.3		
Horizontal alignment of the PSISs (deg)	−0.9 (2.2)	6.9/7.8	55	21

The positive sign indicates inclination to the left and the negative sign indicates inclination to the right. The scapular alignment related to T3 is expressed in centimeters, the other values are expressed in degrees.

The global approach to posture provides a platform for discussion of the standard for normal alignment and its respective deviations. This also fosters the conducting of further studies aimed specifically at posture or that adopt postural assessment as a physiotherapeutic procedure to study the correlations between posture and dysfunctions.[31-34]

The current technological advances allow the use of more precise tools for quantitative analysis that complements the qualitative analysis. A discussion of posture based on average values for various angles requires the use of a resource for quantitative assessment easy to use.

The PAS software used to analyze the photographs in this study was previously submitted to an assessment of interrater and intrarater reliabilities. It was demonstrated to be reliable to perform postural analysis using photographs, but the values obtained with PAS are only reliable if the marking of anatomical points is performed correctly. To reduce errors in the localization of anatomical points, a tutorial (available in the software) was written. Correct localization of the anatomical points is a key prerequisite to ensure the reproducibility and reliability of postural analysis.[3,35,36] The correct placing of the markers at the anatomical points is time consuming but also ensures greater reliability. The variations in measurements described in this study occur within small ranges, such that incorrect placement of markers may seriously jeopardize the results obtained.

With regard to the methodology, all assessments in this study were applied by the same rater. This increases the reliability of data because according to Billi et al[35] and Fedorak et al,[36] intrarater reliability is higher than interrater reliability.

Another important aspect is the verbal instructions given to subjects during the postural assessment. Traditionally in physical therapy, the base of support is set up before starting the assessment with the rationale that this procedure enables later comparison with follow-up assessments. The literature does not fully address this issue. Bullock-Saxton[30] affirms that only comfortable standing posture assumed by the subject at the time of assessment can be representative of true alignment. In this study, it was decided to leave the base of support free to enable the subjects to position their feet naturally over a rubber mat.[13,30] The assumed base was marked out on the carpet and retained in photographs of anterior, posterior, and lateral views, ensuring the same base of support, including the possibility of measuring this base. The distance between the medial malleolus was not used as a parameter to estimate the base of support because this measure does not quantify potential rotations in foot position.

Clinical activity in physical therapy and orthopedic medicine requires anthropometric baseline reference values for postural analysis, and the methodology proposed in this study enables reproducibility at low cost. Future studies with larger samples could therefore establish baseline reference values or the distribution in ranges, instead of normal absolute values.

Limitations

A relatively small sample to define a postural pattern, the assessment of exclusively healthy subjects, and the use of overlapping markers to visualize the spinous lateral view. The ideal approach to establish definitive reference values for upright posture would require a multicenter study, with a larger sample of both healthy subjects and people with disorders, and the results would be presented in ranges of normality for the alignment of each body segment.

The spotting of the anatomical points depends on the evaluator's training and knowledge of anatomy. In spite of the tutorial on anatomy available in the PAS/SAPO software, some anatomical points are harder to find, which can increase measurement errors. Lack of familiarity with the use of the software may impair the performance of the evaluator, but in this study, all tests were conducted by the same individual.

Conclusions

The results of the present study demonstrated a tendency toward asymmetry among bilateral segments in anterior view, with pelvis, shoulders, and trunk showing slight inclinations to the right. In the posterior view, a small asymmetry was observed in positioning of the pelvis and scapula.

The quantitative analysis of the variables regarding postural alignment points to the existence of a standard posture, which is not symmetrical between the left and the right sides, such that slight asymmetry, represents the normative standard for the upright standing posture. This may prevent devising of a single standard assessment able to yield baseline reference values.

Practical Application

- Postural assessment by photography and computational analysis showed slight variations of postural alignment, indicating that posture might have ranges of normal values.

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No funding sources or conflicts of interest were reported for this study.

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