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LITERATURE REVIEW

Photographic analysis of human posture: A literature review

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Summary *Introduction:* The study of posture is not an easy task, mainly because postural assessment is still scientifically inaccurate. Photographs of bipedalism in the frontal and sagittal planes are one of the most widely used methods for this assessment. The aim of this literature review was to determine which anatomical markers authors of scientific papers have taken to minimize the chances of error in measurements.
Materials and methods: The Medline and Lilacs databases were searched for the period from 2002 to 2012, with the following keywords: "postura"; "posture" and "postural."
Discussion: A number of studies have shown a reasonable correlation between radiographic measurements and the placement of markers. It appears possible to use photography as a form of scientific assessment since the anatomical landmarks are well chosen.
Conclusion: The markers that were suggested in this review: malleolus; posterior calcaneal tuberosity; fibular head; tibial tuberosity; greater trochanter of the femur; anterior angle and/or posterior lateral edge of the acromion; spinous processes (particularly C7); inferior angle of the scapula; sternum manubrium; mental protuberance; and the intertragic notch. Iliac spines, both anterior superior and posterior superior, should only be used with lean subjects.

Introduction

The study of human posture is relatively new compared to other areas of medical science. Certain deviations in posture can be unsightly and can adversely affect muscular efficiency, as well as predisposing individuals to musculoskeletal pathologic conditions (Liebenson, 2008; Wallden, 2009; Rosário et al., 2012). Posture can also alter or be

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altered by certain psychological conditions (James et al., 2009; Rosário et al. 2012). However, it is not an easy subject to study, mainly because postural assessments are still scientifically inaccurate. Two methods are widely used for such assessments: the study of the projection of the center of gravity with the aid of a force platform; and photography of the standing posture, using both frontal and sagittal planes (Rosário et al., 2012). Some methods, such as MRI, are expensive, while others, such as X-ray, involve radiation problems (Suzuki et al., 2010; Berthonnaud et al., 2009; Steffen et al., 2010).

The problem with the first approach is purely semantic. Some studies speak of postural analysis as measured by the force platform (Viguier et al., 2009), but this is inaccurate. The force platform measures the oscillation of the body and the association between the projection of the center of gravity and the support base (Bonde-Petersen, 1975), thus providing a balance, not a posture, measurement. Posture is strongly related to balance (Nashner, 1972; Nashner and McCollum, 1985). and its treatment can be similar, but posture is not the same as balance. It is very difficult to imagine a person with good posture and poor balance, but it is possible to imagine bad posture with good balance if the misaligned body segments are compensated so that the resulting projection of the center of gravity is between the feet.

The problem with the second approach is that the adhesive markers are not accurate. These are used in the demarcation of the features adopted as the reference point for calculating distances and angles on the photos (Rosário et al., 2012). Depending on the chosen anatomical region, it is easy to misplace the exact location. Large measurements, such as the distance between the shoulders for example, may not suffer so much with this error. However, smaller distances or angular measurements can be questioned since the displacement of the anatomical point may completely alter the outcome (Rosário et al., 2012).

Therefore, the aim of this literature review was to determine which methodologies have been adopted by authors of scientific works on posture, in order to solve or minimize this problem in photographic assessments, as well as to search for a protocol with less measurement errors which is easily reproducible, both for scientific and clinical objectives.

Materials and methods

Search methods

The Medline and Lilacs databases were consulted for relevant articles from 2002 to 2012 with the keywords "posture" and "postural". Articles needed to be in English, Portuguese, French, Italian or Spanish. Additionally, they needed to have a description of a photographic postural assessment.

Criteria for inclusion and exclusion

According to the objectives two main questions were addressed:

1 Is it possible to use photography scientifically to assess posture? Is there any strategy that minimizes the assessment errors?
2 What landmarks have been used to study posture?

In relation to the first question, articles that correlated the landmarks and other validated measurements, such as radiography or goniometry, were considered.

To answer the second question, all research articles that described the use of photography and landmarks were included.

Empirical research, letters to the editor and conference proceedings were excluded.

Study selection

For all research articles identified during the search, the titles, keywords and abstracts were read in order to confirm if they satisfied the inclusion criteria. Full text copies were obtained for analysis and data extraction for all articles that met the inclusion criteria.

Results

For the first question, 13 studies correlated the landmarks and other validated measurements, thereby satisfying the inclusion criteria.

Twelve research articles were found which used a landmark to assess posture through photographs.

No reviews or case studies were found.

Discussion

1 Validation of the photographic method for postural assessment

Before confirming which points are the most interesting for a photographic assessment, the obvious question is whether the photographic assessment is efficient to find postural deviations. Very few articles were found that validated or invalidated this type of assessment, despite the fact that a discussion of this work is of great importance in order to understand this tool.

A number of studies have reported a reasonable correlation between radiographic measurements and the placement of markers (Hunt et al., 2008; Mundermann et al., 2008; Vanwanseele et al., 2009). Certain authors look for methods to reduce the possibility of error in marking the bony landmarks and the correct placement of joint centers and axes (Bell et al., 1990; Camomilla et al., 2006; Ehrig et al., 2006, 2007; Taylor et al., 2005). Bland and Altman (1995), on the other hand, found some significant errors while correlating certain assessment methods. Smith et al. (2008) compared the alignment of the knee using photographs and X-ray and concluded that photographs are a viable tool for this purpose.

Iunes et al. (2009) studied twenty-one volunteers, who were visually assessed by three experienced physiotherapists and then photographed with markers attached to the skin at various anatomical sites. The photographs, in turn, were analyzed by three other examiners. There was statistical concordance between the examiners who used photogrammetry for all of the segments assessed. The comparison between photogrammetry and visual assessment revealed that the degree of agreement between the two assessment methods was poor for some segments of the lower limb and pelvis. Although it is interesting that this study reported few associations between the visual and photographic assessment, the study contained a methodological error. It concluded that the gold standard would be postural assessment by photograph. The problem with this assessment was the placement of the markers, which was

Table 1 List of anatomical landmarks used for postural assessment and the respective authors that utilized them.

Anatomical landmarks	Authors
First metatarsophalangeal joint	Cobb et al., 2011
Midpoint between the second and third metatarsals	Ferreira et al., 2010
Navicular tuberosity	Cobb et al., 2011
Lateral malleolus	Miranda et al., 2009; Saito et al., 2009; Ferreira et al., 2010; Canales et al., 2010
Medial malleolus	Miranda et al., 2009; Cobb et al., 2011; Ferreira et al., 2010
Posterior tuberosity of the calcaneus	Ferreira et al., 2010
Achilles tendon	Miranda et al., 2009; Ferreira et al., 2010
The midpoint of the calcaneus	Miranda et al., 2009
Fibular head	Miranda et al., 2009; Saito et al., 2009 ; Canales et al., 2010
Tibial tuberosity	Ferreira et al., 2010
Joint line of the knee	Ferreira et al., 2010
Middle of the patella	Ferreira et al., 2010
Medial femoral condyle	Miranda et al., 2009
Greater trochanter of the femur	Miranda et al., 2009; Saito et al., 2009; Ferreira et al., 2010; Canales et al., 2010
Anterior superior iliac spines	Miranda et al., 2009; Saito et al., 2009; Ferreira et al., 2010; Canales et al., 2010; Rosário et al., 2012
Posterior-superior iliac spines	Miranda et al., 2009; Saito et al., 2009; Ferreira et al., 2010; Canales et al., 2010; Rosário et al., 2012
Acromion	Miranda et al., 2009; Thigpen et al., 2010; Ferreira et al., 2010; Canales et al., 2010; Rosário et al., 2012
Coracoid process	Saito et al., 2009
Spinous processes	
C7	Miranda et al., 2009; Motta et al., 2011; Saito et al., 2009; Thigpen et al., 2010; Ferreira et al., 2010; Canales et al., 2010; Engsberg et al., 2008; Cuccia et al., 2009
T1	Miranda et al., 2009; Claus et al., 2008
T3	Miranda et al., 2009; Ferreira et al., 2010
T5	Claus et al., 2008
T6	Miranda et al., 2009
T7	Miranda et al., 2009
T10	Claus et al., 2008
T12	Miranda et al., 2009
L3	Miranda et al., 2009; Claus et al., 2008
L5	Miranda et al., 2009
S2	Claus et al., 2008; Engsberg et al., 2008
Inferior angle of the scapula	Miranda et al., 2009; Saito et al., 2009; Ferreira et al., 2010; Rosário et al., 2012
Manubrium of the sternum	Motta et al., 2011; Rosário et al., 2012
Chin protuberance	Motta et al., 2011
Tragus	Thigpen et al., 2010; Ferreira et al., 2010; Cuccia et al., 2009; Rosário et al., 2012

unique. There was not a separate placement of markers for each physiotherapist, which would have assessed the real intercorrelation of the assessments.

Smith et al. (2008) compared angles of curvature of the spine in photographic and radiographic assessments, both in the standing position and lateral view of 766 teenagers. Since the main focus of this article was the association with pain, the authors did not directly correlate the two types of assessment. However, the classification of the alignment of the thorax, lumbar spine and pelvis was consistent between the two assessments, suggesting the use of photographs to avoid exposing the patients to radiation.

Sacco et al. (2007) studied the reliability of photographic assessment in relation to goniometry of the lower limbs. The authors also compared the use of two different software programs to assess posture: Corel Draw, purchased software for graphic productions; and SAPo, free software specifically designed for postural assessments. Twenty-six asymptomatic volunteers, with no differences greater than 1 cm between the lower limbs were measured for the following data: tibiotarsal; knee flexion/extension; rear foot; and the Q angle, with a manual goniometer and digital photogrammetry. All of the results were similar, except for the Q angle. Based on these results, it can be inferred that the software does not make much difference in the assessment, since all of the trace angles and distances were similar. The photograph is therefore quite close to goniometry in terms of the assessment result.

The results of these studies, although at times contradictory, demonstrate that there is a possibility of scientifically assessing posture through photographs. The technique that currently exists is still not perfect. This leads to the second question to be answered. Which anatomical sites are safer, in terms of a reduction of methodological errors?

2 Location of the points

At this part of the review, studies that analyzed posture with photographs were considered. None of these articles set out to find the best landmark, but it is interesting to note the solutions used by these authors. The angles and distances used were not part of the scope of this review. Table 1 displays the landmarks used in the studies reviewed. Fig. 1 shows examples of landmark dispositions.

In the table above it is notable that the spinous process of the seventh cervical vertebra is the most common anatomical landmark used. This point is relatively easy to find and can be used for many measurements of the spine, head and shoulders. Other spinous processes are commonly marked and used together to measure lordosis, kyphosis and scoliosis. However, care must be taken when counting the vertebrae and small Styrofoam balls, glued with double sided tape, should be used for lateral view photographs, as reported in the work of Canales et al. (2010) and Ferreira et al. (2010).

The malleoli, fibular head, and greater trochanter of the femur are also widely used, probably because they are small bony prominences and are easy to access. Less common, but with the same localization logic are tibial tuberosity, chin protuberance, manubrium of the sternum and posterior calcaneal tuberosity.

The anterior superior and posterior superior iliac spines deserve special attention. These points are widely used, but are more difficult to find due to increased abdominal fat. Therefore, the scientific use of these points must be associated with a control parameter of this tissue, such as the body mass index or abdominal cirtometry, so as not to compromise the examination.

The inferior angle of the scapula is also an interesting point, which is easy to find, and thus less likely to lead to a methodological error. On the other hand, the acromion is a relatively large spot and requires a more specific point. The middle of the patella can easily generate errors, unless a tape measure is used to find the exact center. However, the patella can be dislocated in some people and lead to an assessment error despite its central point being perfectly located. The midpoint of the calcaneus is also a bad location, since it is a large and irregular bone. The posterior

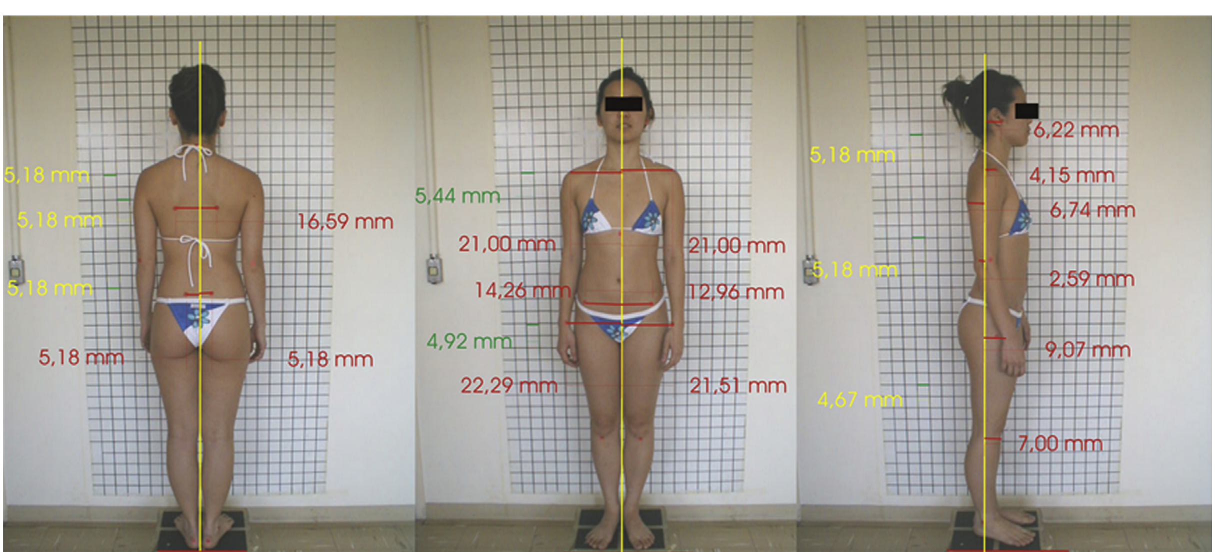

Figure 1 Examples of pictures of the frontal plane with ventral and dorsal incidence and sagittal plane. Landmarks were used in order to calculate postural deviations with the Corel Draw™ software.

calcaneal tuberosity seems to be a good substitute. The same problem exists with the femoral condyles: it's very easy to make a mistake, because their size causes confusion in terms of their exact location.

The Achilles tendon is often used to evaluate the position of the hind foot. However, despite its clinical value, it is difficult to find a precise point for photographic measures through the tendon alone. If the point is poorly chosen, which can easily happen due to the length of the tendon, this may result in alterations of the measurement angles. The midpoint between the second and third metatarsal is also a vague point. The joint line of the knee may also not be a good choice, because it is not a point but a region.

One exception to the points that are not a bony landmark is the tragus, which is a small and well-defined structure and as such is an easy location to find. In order to increase reliability, it is possible to use the intertragic notch at this region, which is even smaller and better defined.

Conclusion

Postural assessments using photographs have produced satisfactory results when compared to other methods such as X-Ray. It is possible to choose points that are easier to find in order to increase the degree of reliability. Based on this review, the following points are suggested: malleoli; posterior calcaneal tuberosity; fibular head; tibial tuberosity; greater trochanter of the femur; angle anterior and/or posterior to the lateral edge of the acromion; spinous processes (in particular C7); inferior angle of the scapula; manubrium of the sternum; chin protuberance; and the intertragic notch. Iliac spines, both posterior superior and anterior superior, should only be used in lean subjects. Further studies involving comparisons between points located by experienced therapists and X-ray should be performed in order to strengthen the validation or to confirm an acceptable amount of error for a non-invasive and non-aggressive postural assessment.

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