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Original Article

Reliability of photographic posture analysis of adolescents

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Abstract. [Purpose] Postural problems of adolescents needs to be evaluated accurately because they may lead to greater problems in the musculoskeletal system as they develop. Although photographic posture analysis has been frequently used, more simple and accessible methods are still needed. The purpose of this study was to investigate the inter- and intra-rater reliability of photographic posture analysis using MB-ruler software. [Subjects and Methods] Subjects were 30 adolescents (15 girls and 15 boys, mean age: 16.4±0.4 years, mean height 166.3±6.7 cm, mean weight 63.8±15.1 kg) and photographs of their habitual standing posture photographs were taken in the sagittal plane. For the evaluation of postural angles, reflective markers were placed on anatomical landmarks. For angular measurements, MB-ruler (Markus Bader- MB Software Solutions, triangular screen ruler) was used. Photographic evaluations were performed by two observers with a repetition after a week. Test-retest and inter-rater reliability evaluations were calculated using intra-class correlation coefficients (ICC). [Results] Inter-rater (ICC>0.972) and test-retest (ICC>0.774) reliability were found to be in the range of acceptable to excellent. [Conclusion] Reference angles for postural evaluation were found to be reliable and repeatable. The present method was found to be an easy and non-invasive method and it may be utilized by researchers who are in search of an alternative method for photographic postural assessments.
Key words: Adolescents, Posture assessment, Reliability

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INTRODUCTION

Correct upright posture is defined as the most suitable orientation of the spinal segments and each part of the body compared to the adjacent segment as well as to the whole trunk[1)]. Correct upright posture is one of the markers of a healthy musculoskeletal system. The Posture Committee of the American Academy of Orthopedic Surgeons defines good posture as "the state of muscular and skeletal balance which protects the supporting structures of the body against injury or progressive deformity, irrespective of the position (erect, lying, squatting, or stooping) in which these structures are working or resting"[2)]. The increasing incidence rate, and consequentially increasing cost, of musculoskeletal injuries has resulted in an increase in research studies investigating ways to maintain correct upright posture.

There exists no standard procedure for posture analysis. In the last decade, several methods have been developed for performing more accurate postural assessments in the standing position. The latest technological developments have allowed the use of several highly reliable and easy-to-use methods, such as X-ray scanners[4–6)] and computerized photographic systems[7)]. There exist several methods for the objective evaluation of the spinal posture, which can basically be classified into 5 groups, namely, radiography[8)], three-dimensional motion analysis via electromagnetic and optical tools[2, 3)], raster stereography[10, 11)], photographic posture analysis[9, 12)], and manual methods. Even though X-ray provides clear images of reference points and therefore is the golden standard in the literature, it is not preferred in extended studies because it involves radiation. Three-dimensional motion analysis is valid and reliable but requires costly equipment and lab conditions; therefore, it is not used very frequently. Video raster stereography analysis enables an automatic calculation of the spinal motion through its multi-directional high-resolution video recording. This method has been proven to be reliable, but it did not receive a pass in validity studies[13)]. There are several manual methods, such as, manual goniometer, electrogoniometer, flexible ruler, and observational posture analysis using the line of gravity.

Photographic posture analysis may be considered as a basic and observational measurement method, like other similar methods, such as observational analysis using the line of gravity[14)], flexible ruler[15)] and posture analysis using

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Table 1. Demographic characteristics of the participants

	16-year-old girls (n=6)	17-year-old girls (n=9)	16-year-old boys (n=6)	17-year-old boys (n=9)	Total (n=30)
	X±SD	X±SD	X±SD	X±SD	X±SD
Height (cm)	163.2±4.9	161.0±5.4	170.7±7.0	169.6±4.85	166.3±6.7
Weight (kg)	59.0±7.2	56.9±6.0	63.1±12.2	68.7±21.6	63.8±15.1
Body Mass Index (kg/m²)	22.1±2.3	21.9±2.4	22.7±8.1	23.04±4.54	23.0±5.0

palpation[16]; however, since this method enables angular calculations using anatomical reference points, it is a digital, more objective measurement method. Reliability studies of photographic manual posture analysis have been also performed using subjects other than adults[7, 10, 17]. Clinical use of photographic posture analysis is recommended in the literature because it is an accurate and objective method[18].

The present study aims to investigated the inter- and intra-rater reliability of this convenient and accessible photographic posture analysis of adolescents using MB-Ruler Software 5.3 version[19].

SUBJECTS AND METHODS

The subjects were 30 volunteer adolescents attending high school in a rural region of Turkey (Table 1). Individuals with musculoskeletal problems, gait abnormalities, neurological diseases affecting balance, and those who declined to participate in the study were excluded.

Local Ethics Committee approval was obtained (Non-interventional Clinical Research Ethics Board reference GO 13/94-14) and all subjects consented to participation in the study. Informed consent was obtained from each patient regarding the risks, benefits, and the duration of the intervention.

Postural assessment was carried out using the photographic method[10, 20]. The procedures utilized by Pausic et al. were followed[20]. The camera to be used for taking photographs of the participants was placed 1.5 m away from the subjects on a tripod, at a height of 115 cm height to the camera. To maintain the same distance between the camera and the subjects, a spot on the ground was marked for the subjects to stand on and the tripod was taped on to the floor. The subjects stood barefoot and in a standing position, the photos were taken from the subjects' right hand side.

Before taking the photographs, for more accurate and easier angular calculations, reflective markers were taped on some reference anatomical points of to the patients as listed below: eye canthus, tragus, trochanter major, anterior superior iliac spine (ASIS), 7th cervical spinous process, 12th thoracic spinous process, and lateral malleolus.

Participants were informed before the evaluation. They were asked to look ahead and stand in a comfortable position. To make sure that the reflective markers on ASIS and the trochanter major were visible, the participants were asked to put both hands together in front of their chests.

The angles calculated for the posture analysis, the following angles were evaluated are described below.

The cranio-horizontal angle is formed by the horizontal line through ear tragus and the line connecting the eye canthus to the tragus. This angle gives information about the position of the upper cervical region and the field of vision[21].

The cranio-vertebral angle is formed by the horizontal line through C7 and the line connecting C7 with tragus. It gives information about the position of the head above the neck. The normal angular value varies between 25 to 31 degrees. An increase in this angle is named as 'pooking chin' and it is an indication of stress on the upper cervical region[10]. A decrease in this angle is an indication of the anterior tilt of the head and is associated with neck pain[21–25].

The trunk angle is formed by the line connecting C7 and the trochanter major and a vertical line drawn to the trochanter major. It informs about the orientation of the trunk in relation to the line of gravity. A decrease in trunk angle shows the relative posterior tilt of the trunk[10].

The lumbar angle is formed by the line through T12 and ASIS and the line through ASIS and the trochanter major[13, 26, 27].

The sway angle is formed by the line connecting C7 with the trochanter major and the line connecting the trochanter major with the lateral malleolus[13, 27]. This angle gives information about the position of the hip relative to the ankle support surface, and thus the center of gravity. An increase in this angle results in increased postural control due to the shift of the center of gravity from over the heel to the foot[10].

In the present study, MB-Ruler (Markus Bader- MB Software Solutions, triangular screen ruler) computer software was used. This software simply uses an on-screen goniometer and it was selected because it is easy to use and conveniently available online.

The pictures of the adolescents were seperately evaluated by 2 different observers separately. The observers repeated the evaluation one week later for test-retest analysis.

The normality of the variable distributions was analyzed visually (histogram and probability charts) and via analytical methods (Kolmogorov-Smirnov/Shapiro-Wilk tests). For descriptive analyses, the first evaluation of the first observer was used and presented as the mean and standard deviation. For inter-rater reliability, the intraclass correlation coefficient (ICC) 2.1, and for test-retest reliability, interclass correlation coefficient ICC 3.1 was used. Statistical significance was accepted for the values of $p<0.05$.

RESULTS

In the present study, 30 volunteer adolescents (15 boys and 15 girls) with an age range of 16–17 years were included and they were evaluated using photographic posture analysis

Table 2. Inter- and intra-rater reliabilities of the observers (Units: r^2)

Angle (degree)	Observer 1 X±SS		Observer 2 X±SS		ICC[1]	ICC[2]
Cranio-vertebral	48.4±4.9	48.4±5.4	48.4±5.4	48.4±4.9	0.984	0.983
Cranio-horizontal	21.2±8.1	20.8±8.7	20.8±8.7	20.8±8.4	0.989	0.990
Trunk angle	169.5±2.4	169.6±2.6	168.0±3.0	169.2±2.8	0.774	0.985
Lumbar angle	111.7±9.7	111.6±9.7	111.0±9.8	110.0±9.3	0.996	0.993
Sway angle	164.3±3.5	164.5±3.7	164.3±3.7	164.2±3.6	0.973	0.972

[1]ICC test-retest reliability, [2]ICC inter-rater reliability

(Table 1). The demographic data of the participants are presented in Table 1.

Excellent correlations were observed between two evaluations of the same observer on the same photograph in terms of the cranio-vertebral, cranio-horizontal, lumbar, and sway angles (ICC values varied between 0.973 and 0.996). The correlation of the trunk angle measurements was found to be acceptable (Table 2).

There was an excellent correlation between the two observers in the analyses of the five angles and the calculated ICC values ranged between 0.972 and 0.993 (Table 2).

DISCUSSION

In the present study, the inter-rater and test-retest reliabilities of the photographic posture anlaysis using MB-ruler software for the evaluation of 5 angles were investigated with a group of adolescents as subjects, and they were found to be reliable, confirming the hypothesis of our study.

The study had completed with 30 participants and it was found that, in the evaluation of the 5 angles, the inter-rater reliability (ICC>0.972) and test-retest (ICC>0.774) reliability of the MB-ruler method was in the range of acceptable to excellent. This is an important result considering the fact that MB-ruler software goniometer which can be used for the evaluation of postural angles.

In the present study inter-rater and intra-rater ICC classifications were made based on Ferreira et al. ICC values are grouped as follows: ICC<0.70 non-acceptable, 0.71<ICC<0.79 acceptable, 0.80<ICC<0.89 very good, and ICC>0.90 excellent[7]. All ICC values found for all of the 5 angles were categorized as “acceptable” or “excellent” groups, which showing that the MB-ruler method is reliable. The lowest ICC value, 0.77, was obtained for the trunk angle, an acceptable group value.

In the literature, there are several reliability studies of the same 5 angles in the present study, which utilized with different methods and in different age groups. McEvoy et al.[10] measured 38 boy and girl volunteers with an age range of 5–12 and reported an ICC values of 0.93 and more. Perry et al.[13] measured volunteers with an age range of 13–17 and reported 0.40–0.75 inter-rater reliabilities of 0.75–0.90 intra-rater reliability. Pusic et al.[20] investigated the reliability of manual and automatic measurements in photographic posture analysis and reported that both methods were sufficiently reliable (automatic ICC 0.81–0.92, and manual ICC 0.80–0.91) at measuring the angles used in photographic posture analysis. The most important feature of the present study was that an easy-to-access online MB-ruler program was used for the measurement of the angles. Angular calculations using MB-ruler have been reported in the literature[28–30]. The findings of the present study showed that postural measurements made using the reference points and the MB-ruler software were reliable.

The reliability of MB-ruler is important also because it is a very convenient tool to be used in survey studies. Postural problems more frequently occurring in the developmental periods and may be painful and also may have a negative impact on the quality of life in adulthood by causing musculoskeletal problems[31]. Therefore, postural surveys of adolescents are of great importance. The subjectivity of the existing measurement methods, and the fact that more objective and reliable methods are costly and require equipment that is difficult to carry are among the difficulties of conducting postural surveys of a healthy population. In addition, interpretation and analysis of 3-dimensional posture evaluation require training[6]. Perry et al.[13] studied the factors affecting the reliability of photographic posture analysis and reported that a few fundamental factors, such as observers qualified in finding bony reference points, the orientation of the camera, and trunk compositions, have an effect on angle calculations. They also reported that photographic posture analysis is a cheap and simple method of posture analysis. The most important features of the method used in the present study are that it is easy-to-use, portable, and cheap.

Pausic et al.[20] reported that the most important limitation of their study was the inclusion of only male participants. Even though it has been reported that gender differences do not have an effect on the reliability of angular measurement in postural analysis, participants of both genders were equally present in the present study.

It was observed that the reference angles investigated in the present study were reliable and repeatable. The method whose reliability was shown to be reliable and may be used as an alternative photographic posture analysis method in extensive field surveys because it is more economical and more convenient in terms of both availability and application.

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