The reliability and validity of body vision system for assessing posture

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Abstract

Introduction: Body vision is a novel method which examines postural indices through photogrammetric essentials. Nevertheless, its reliability and validity has not been appraised till now. We aimed to evaluate the reliability and validity of body vision system for posture assessment.

Methods: This was a cross-sectional study in which two examiners evaluated photographs of 71 subjects using body vision system twice with a two-week interval. The body vision system involves a grid wall and a camera fixed in front of the grid wall at about 390 cm distances. Three standing photographs (anterior, right lateral, and posterior view) were captured for participants.

Results: The results for inter-rater reliability analysis showed that most of the parameters (74%) had excellent 95% confidence interval (CI), 10 % had good to excellent 95% CI, 13% had moderate to good 95% CI, and 1% had poor to moderate 95% CI. The results for intra-rater reliability analysis showed that 70%-72% of the parameters had excellent 95% CI, 6%-9% had good to excellent 95% CI, 12%-13% had moderate to good 95% CI, and 9% had poor to moderate 95% CI. The comparison between known distances and angles on grid wall and those obtained from photogrammetric measurements showed that there was no statistically significant difference (P > 0.05). Also, the regression analysis showed that there was a significant and positive relationship between them (R2 = 1, P<0.05).

Conclusion: The results of this study showed that body vision system is a valid and reliable tool for measuring postural parameters.

Introduction

Posture is the alignment between different parts of body. A good posture is where the musculoskeletal structures bear least stress due to balance between different components.1,2 Deviations from proper postural alignment indicate that the balance has been disturbed and some parts are at risk of injury because of excess load.1 Also, postural analysis has shown that disorders like spondylolisthesis,4 adolescent idiopathic scoliosis,5 osteoporosis, pain,6 and nasal patency7 might affect the subject's posture which causes additional problems.8

Posture assessment can be done with X-ray exam which might expose radiation or noninvasive methods like visual inspection, goniometry, photogrammetry and 3D laser scan.9,10

Photogrammetry is a simple and safe method for analyzing posture in a quantitative manner. There are different types of software programs like postural assessment software (SAPO) and Surgimap which helps to measure postural parameters faster and easier. The reliability of measurements using most of these software packages has been investigated previously. Body vision is a new system which analyzes postural parameters using photogrammetric basics. However, the reliability and validity of the measurements using body vision system has not been evaluated till now.

The purpose of this study was to determine the inter-rater and intra-rater reliability and validity of postural analysis using body vision system.

Methods

Subjects

Photographs were chosen from databases of posture assessment clinic of Imam Reza hospital. The protocol...
was reviewed and approved by Physical Medicine and Rehabilitation Research Center. The subjects wearing clothes more than underwear were excluded and 71 subjects remained for analyses. The objectives and the process of the study were explained and written informed consent was completed for each subject. The subjects were able to retract the projects during the study, without providing any reason. All subjects had three standing photographs (anterior, right lateral, and posterior view), looking forward and arms at sides. All photographs had been captured by posture clinic assistant who had marked some anatomical points with 1.5 * 1.5 cm sticking spheres. The percent of identified (and visible) markers in each view was as follows:

**Anterior view:** Greater trochanter 22.5%, ASIS 95.7%, suprasternal notch 15%, xiphoid 6%, acromion 6%.

**Lateral view:** Greater trochanter 9%, ASIS 91%, PSIS 100%, C7 spinous process 92.9%, T7 spinous process 62%, T12 spinous process 65%, suprasternal notch 15%, acromion 6%.

**Posterior view:** PSIS 100%, C7 spinous process 95%, T7 spinous process 63%, T12 spinous process 64%, inferior angle of scapula 15%.

**Body vision**

The body vision system consists of an 80*195 cm grid wall (with 10 cm sectors) and a camera (CANON Zoom Lens EF-S 18-55 mm 1:3.5-5.6 IS II 58 mm) which has been fixed in front of the grid wall at about 390 cm distance (on about 100 cm height). The camera is connected to the computer and examiner can take photos, restore them and analysis different angle and distance parameters of posture using the body vision software (Table 1). In this version of body vision software, the examiner has to identify different landmarks. The device has been developed in Tabriz, Iran by Tocea Tadbir Tavan Teb Company (Rehabsoon Co).

**Procedures**

Two physical therapists who were familiar with the use of the software were randomly chosen from students of Physical Medicine and Rehabilitation Department of Tabriz University of Medical Sciences. Evaluation of photographs was done using body vision software. The examiner defined the plumb line and then other landmarks orderly as shown in Figure 1. Each examiner evaluated the photographs twice with a two-week interval. The third investigator exported reports of each test in an excel form, stored them in other file and cleaned from software database in order to not allowing the examiners to see previous analysis.

To evaluate the validity of measurement, we used distances and angles on grid wall as the reference value and asked the examiners to mark and measure them using the body vision software. In order to perform blinding, the examiners were not allowed to see the results of measurements and the third investigator gathered the data.

**Statistical analysis**

The intra-rater reliability of measurements was evaluated by intraclass correlation test (ICC two ways mixed, average, absolute agreement). The inter-rater reliability of measurements was evaluated by ICC test (two ways random, average, absolute agreement). It has been suggested to define poor, moderate, good and excellent results if the ICC values equals to less than 0.5, 0.5 to 0.75, 0.75 to 0.9 and greater than 0.9, respectively. Paired t test and regression analysis were used to evaluate the validity of measurements.

All analysis was done using SPSS software 16 and P value less than 0.05 was considered significant.

**Results**

The mean age of subjects was 21.13 years old (ranging from 4 to 67 year) and 62% of them were male.

The results for inter-rater reliability analysis showed that most of the parameters (74%) had excellent 95% confidence interval (CI), 10 % had good to excellent 95% CI, 13% had moderate to good 95% CI, and 1% had poor to moderate 95% CI (Table 2).

The results for intra-rater reliability analysis showed that 70%-72% of the parameters had excellent 95% CI, 6%-9% had good to excellent 95% CI, 12%-13% had moderate to good 95% CI, and 9% had poor to moderate 95% CI.

The comparison between known distances and angles on grid wall and those obtained from photogrammetric measurements showed that there was no statistically significant difference ($P > 0.05$). Also the regression analysis showed that there was a significant and positive relationship between them ($R^2 = 1$, $P < 0.05$) (Table 3).

**Discussion**

According to the results obtained in this study, most parameters had good to excellent inter-rater and intra-rater reliability. The low levels of reliability in some parameters might be attributed to the low resolution of the photographs or hiding of the markers due to relaxed position of the subject, for example in the case of tibial tuberosity or greater trochanter landmarks, respectively. So, it is necessary to mark those landmarks which might not be clear in photo and all landmarks should be visible; otherwise, the analysis will not be reliable. The results of other studies using different software were the same. Souza et al. have shown that postural assessment software (SAPO) is a reliable tool for postural analysis when bony landmarks were identified before photogrammetry. Santos et al and Hazar et al have found same results in children and adolescents, respectively. Helmya et al have shown that the Surgimap spine software is a reliable tool for posture assessment when placing markers on certain anatomical landmarks. Muniaidy et al concluded that web plot digitizer software was a reliable tool to assess forward
<table>
<thead>
<tr>
<th>Parameter Description</th>
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<tr>
<td>Head lateral tilt angle</td>
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<td>Head inclination angle</td>
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<td>Mid-head - plumb line distance</td>
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<td>Shoulder tilt angle</td>
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<td>A21</td>
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<td>Trunk sway angle</td>
<td>A22</td>
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Table 1. Definition of postural parameters

- **Head lateral tilt angle (A1)**: The angle formed between the line connecting right and left tragus with the horizontal line.
- **Head inclination angle (A2)**: The angle between the line connecting glabella and chin protuberance with vertical line through chin protuberance.
- **Mid-head - plumb line distance (D1)**: The horizontal distance of mid-head line (the line connecting glabella to the chin protuberance) from plumb line in the chin protuberance point which indicates head rotation.
- **Shoulder tilt angle (A3)**: The angle formed between the line connecting right and left acromion process with the horizontal line.
- **Mid-chest - plumb line distance (D2)**: The horizontal distance of mid-chest line (the line connecting xiphoid process to the suprasternal notch) from plumb line in the suprasternal notch point.
- **Umbilicus-plumb line distance (D3)**: Horizontal distance of umbilicus from plumb line.
- **Pelvic lateral tilt angle (A4)**: The angle formed between the line connecting ASISs with the horizontal line.
- **Shoulder on pelvis tilt angle (A5)**: The angle formed between the line connecting right and left acromion process and the line connecting right and left ASISs.
- **Greater trochanter tilt angle (A6)**: The angle formed between the line connecting right and left greater trochanter with the horizontal line.
- **ASIS to greater trochanter distance (D4)**: Distance between the ASIS and greater trochanter on same side.
- **Q angle (A7)**: The angle formed between the line connecting ASIS to patellar center and the line connecting tibial tuberosity to the patellar center.
- **Lateral thigh leg angle (A8)**: The angle formed between the line connecting greater trochanter to lateral mid knee joint line and the line connecting lateral mid knee joint line to the lateral malleolus in anterior view.
- **Femoral-tibial angle (anatomic knee angle) (A9)**: The angle between distal part of thigh and proximal part of leg.
- **Intercondylar distance (D5)**: Horizontal distance between right and left medial femoral condyles.
- **Tibial tuberosity tilt angle (A10)**: The angle formed between the line connecting right and left tibial tuberosity with the horizontal line.
- **Femoral segment length (D6)**: Distance between greater Trochanter and lateral mid knee joint line on each side.
- **Tibial segment length (D7)**: Distance between lateral mid knee joint line and lateral malleolus on each side.
- **Lateral malleolus tilt angle (A11)**: The angle formed between the line connecting right and left lateral malleolus with the horizontal line.
- **Internalmalleolar distance (D8)**: Horizontal distance between right and left medial malleolus.
- **True leg length (D9)**: Distance between the ASIS and medial malleolus on same side.
- **True discrepancy (D10)**: Difference between right and left true leg length.
- **Apparent leg length (D11)**: Distance between the umbilicus and medial malleolus on same side.
- **Apparent discrepancy (D12)**: Difference between right and left apparent leg length.
- **Head gaze angle (A12)**: The angle formed at the intersection of a horizontal line through the ear tragus and a line connecting the ear tragus with the lateral eye canthus.
- **Head horizontal angle (A13)**: The angle formed at the intersection of a horizontal line through the C7 spinous process and a line connecting the C7 spinous process with ear tragus.
- **Head vertical angle (A14)**: The angle formed at the intersection of a vertical line through the C7 spinous process and a line connecting the C7 spinous process with ear tragus.
- **Head positional angle (A15)**: The angle formed between tragus-chin protuberance line and tragus-suprasternal notch line. Indicate the vertical distance between the chin and sternum.
- **Tragus -plumb line distance (D13)**: The horizontal distance of ear tragus from plumb line.
- **Shoulder angle (A16)**: The angle formed at the intersection of the line between the midpoint of the humerus head and spinous process of C7 and the horizontal line through the midpoint of the humeral head.
- **Acromion-plumb line distance (D14)**: The horizontal distance of acromion from plumb line.
- **Thoracic kyphosis angle (A17)**: The angle formed by the straight lines between the C7 spinous process and the spinous process of T12 and that intersects the horizontal line between T7 (between T6 and T8) and the true vertical line.
- **Lateral spinal angle (A18)**: The angle formed between the line connecting C7 spinous process to T12 and the line connecting T12 to the greater trochanter.
- **Lumbar lordosis angle (A19)**: The angle formed by the straight lines between the T12 spinous process and the spinous process of L5 (between L4 & S2) and that intersects the horizontal line between L3 (between L2 & L4) and the true vertical line.
- **Lateral lumbar angle (A20)**: The angle formed between the line connecting T12 spinous process to ASIS and the line connecting ASIS to the greater trochanter.
- **Pelvic tilt angle (A21)**: The angle formed between the line connecting ASIS and PSIS and a horizontal line through PSIS.
- **Trunk sway angle (A22)**: The angle formed between the line connecting greater trochanter and acromion and a vertical line through greater trochanter.
head posture when using marker placement. Szucs and Brown had found same results about mobile application for posture analysis. Salahzadeh et al showed that the level of ICC to assess the reliability of photogrammetry was ranged from 0.75 to 0.94 when examining forward head and the intra subject reliability was 0.84 to 0.89. Ferreira et al found that the SAPO software would be a reliable tool for posture analysis. Salahzadeh et al showed that the head posture measurement with visual assessment to obtain the validity of photometric method. Marques et al showed that goniometry and photogrammetry measurements of hip abduction and flexion have comparable results. However, Antonioli et al found that the position of feet did not interfere with the results of the posture assessment.

Another aspect of using a measurement method is the validity which explain how results are accurate. The validity of any measurement tool could be assessed when comparing the results with those obtained using standard methods.

Walicka-Cupryś et al have shown that the results of photogrammetry and inclinometer are comparable to measure thoracic kyphosis and lumbar lordosis. Ludwig et al had compared the photometric method for posture index measurement with visual assessment to obtain the validity of photometric method. Marques et al showed that goniometry and photogrammetry measurements of hip abduction and flexion have comparable results.

However, the different landmarks in each test or different unit calculation might cause differences between results of various methods. As Marchetti et al had shown there might be ± 5.9 and 6.9-degree difference when comparing spinous process marker for measuring
<table>
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<th>Head Lateral Tilt</th>
<th>Examiner A</th>
<th>ICC</th>
<th>95% CI*</th>
<th>Examiner B</th>
<th>ICC</th>
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<th>Examiner C</th>
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cobb angle with the standard method. Wilczyński et al have compared photogrammetry and radiology for spinal curvature diagnosis and they have found that there is a significant but low correlation between them. Döhnert and Tomasi found that photogrammetry would not be useful for screening and diagnoses of mild scoliosis. Each parameter of posture assessment could be evaluated with its standard method of diagnosis. Although there are different gold standard methods like X-ray, goniometry, inclinometer, etc to diagnose postural abnormalities, the aim of this study was not to compare all these with photogrammetry but it was to investigate how measurements are accurate. Therefore, we defined fixed points on the grid wall with known distances and angles and compared the value of each parameter with those obtained by photogrammetry. Schwertner et al had used similar way to verify the validity of SPGAP (posture evaluation rotating platform system). They compared the values obtained through SPGAP system measurement of an object with its known dimensions. Ruivo et al used the metal pieces and goniometer as the reference values for assessing the validity of SAPO software. Ferreira et al also had used an object with known distances and angles to investigate the validity of SAPO software. They found that the mean difference for angle and distance measurement were 0.11 degree and 1.8 mm, respectively. We found that the mean difference for angle and distance measurement were 0.02 degree and 0.03 mm, respectively. There was no statistically significant difference (P > 0.05) and the correlation between measurements was almost complete (R² = 1). The magnification error of measurements was 0.02 which is inevitable in two dimensional analyses. So, it could be said that the body vision is a reliable and valid tool for analysis of postural parameters.

Standing posture is not static and may change during time. Sacco et al found that photogrammetry is not suitable for follow up purposes because the intra-subject reliability of rear foot angle measurement is low when analyzing the subjects with one-week interval. In this study, we did not examine intra-subject reliability which is necessary to be evaluated in future studies. The experience of examiner whom marks the anatomical points, as well as the computer experience of examiners might affect the results and have to be investigated.

**Conclusion**

It could be claimed that the use of body vision system is a reliable and valid tool for measuring postural parameters. Although the measures are reliable and valid, the utility of these analyses should be investigated in follow up studies.

| Table 3 Analysis of the difference and association between photogrammetry and standard values |
|-----------------|------------------------------|-----------------|-----------------|
| **n** | **Distance (cm)** | **Angle (degree)** | **Differences** | **P value** | **R²** | **P value** |
| 100 | 0.003 ± 2.19 | 0.98 | 1.00 | 0.000 |
| 81 | 0.02 ± 0.32 | 0.43 | 1.00 | 0.000 |

*Data are presented as mean ± SD.

*Paired t test.

*Regression.

**Study Highlights**

What is current knowledge?
- Body vision is a novel method which examines postural indices through photogrammetric essentials.
- Nevertheless, its reliability and validity has not been appraised till now.

What is new here?
- The body vision system is a valid and reliable tool for measuring postural parameters.
Conflict of Interest
Authors declare no conflict of interest in this study.

Ethic Approval
This research was approved by regional ethic committee of Tabriz University of Medical Sciences (IR.TBZMED.REC.1395.1174).

Authors’ Contribution
YS and NAF contributed to conception and design of the study and literature review. MA, AE and HH collected the data and contributed to data interpretation and drafting the manuscript. NAF and ND. drafted the first manuscript. All authors reviewed and approved the final version of the article.

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