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Intra- and inter-examiner reliability of head alignment assessment in sitting and standing positions

Confiabilidade intra e interexaminador da avaliação do alinhamento da cabeça nas posições sentado e em pé

La exactitud intra y entre examinador en la evaluación de la alienación de la cabeza en las posturas sentada y de pie

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ABSTRACT | To verify the intra- and inter-examiner reliability of the head anteriorization and inclination angles in the front and side views in sitting and standing positions and whether or not the measurements differ from the positions used. 78 people participated, aged 23.5±5.8 years old, 63.7 ± 10.3 kg of weight, and 166.5 ± 8.2cm of height. The people were photographed in standing and sitting positions, following the protocol of Postural Assessment Evaluation Software (PAES). The horizontal head alignment was analyzed in anterior and lateral views (HHA_A; HHA_L). The vertical head alignment was analyzed in lateral view (VHA_L). Three evaluators analyzed the images, repeating the analysis seven days later. Interclass Correlation Coefficient (ICC) and paired t-test were applied with significance level of p≤0.05. From the inter-examiner reliability analysis, 3 out of the 6 evaluated angles were rated as excellent, 1 as acceptable and 1 as unacceptable. Regarding the level of intra-examiner reliability, in 10 assessments the ICC was rated as excellent, in 6 as very good, in 1 as acceptable and in 1 as unacceptable. No differences were observed between sitting and standing positions in the assessments made. The evaluations of head anteriorization and inclination angles in anterior and lateral views in sitting and standing positions were reliable when made by different examiners or by the same examiner in different days. Additionally, it was confirmed that evaluation results do not depend on the position used.

Keywords | Photogrammetry; Posture; Software; Evaluation.

RESUMO | Objetivou-se verificar a confiabilidade intra e interexaminador dos ângulos de anteriorização e de inclinação da cabeça nas vistas anterior e lateral nas posições sentado e em pé e se as medidas independem da posição utilizada. Participaram 78 sujeitos com 23,5±5,8 anos, 63,7±10,3 kg e 166,5±8,2 cm de estatura. Os sujeitos foram fotografados nas posturas em pé e sentado, seguindo o protocolo do Software para Avaliação Postural (SAPO). Foram analisados o alinhamento horizontal da cabeça nas vistas anterior e lateral (AHC_A; AHC_L) e o alinhamento vertical da cabeça na vista lateral (AVC_L). Três avaliadores analisaram as imagens, repetindo essa análise sete dias depois. O coeficiente de correlação intraclasse (ICC) e o teste t pareado foram aplicados, com nível de significância de p≤0,05. Na análise da confiabilidade interexaminadores, dos seis ângulos avaliados, três foram classificados como excelentes, um como

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aceitável e apenas um como não aceitável. Quanto ao nível de confiabilidade intraexaminador, em dez avaliações o ICC foi classificado como excelente, em seis como muito bom, em uma como aceitável e somente em uma como não aceitável. Não foram observadas diferenças entre as posições sentado e em pé nas diversas avaliações realizadas no estudo. Concluiu-se que as avaliações dos ângulos de anteriorização e inclinação da cabeça nas vistas anterior e lateral e nas posições sentado e em pé mostraram-se confiáveis quando realizadas por examinadores diferentes ou pelo mesmo examinador em dias diferentes. Adicionalmente, constatou-se que os resultados das avaliações independem da posição utilizada.

Descritores | Fotogrametria; Postura; Software; Avaliação.

RESUMEN | Se evalúa la exactitud intra y entre examinador de los ángulos anteriores y de inclinación de la cabeza en las vistas anterior y lateral durante las posturas sentada y de pie, así como si hay dependencia de las mediciones en las posturas empleadas. Participaron 78 sujetos de 23,5±5,8 años, 63,7±10,3 kg y 166,5±8,2 cm de estatura. Se fotografiaron a los sujetos en las posturas de pie y sentada, siguiendo el *software* de Evaluación Postural (SAPO). Se analizaron la alienación horizontal de la cabeza en las vistas anterior y lateral (AHC_A; AHC_L) y la alienación vertical de la cabeza en la vista lateral (AVC_L). Tres evaluadores analizaron estas imágenes, y lo repitieron después de siete días. Se emplearon el coeficiente de correlación intraclase (ICC) y la prueba pareada, con un nivel de significación de p≤0,05. En el análisis de la exactitud interexaminador, de seis ángulos evaluados, tres fueron excelentes, uno aceptable y sólo uno no aceptable. En cuanto al nivel de exactitud intraexaminador, el ICC fue excelente en diez evaluaciones, muy bueno en seis, aceptable en una y no aceptable en solamente una. En las posturas evaluadas en este estudio no se observó diferencias. Se concluye que las evaluaciones de los ángulos anteriores y de inclinación de la cabeza en las vistas anterior y lateral y en la postura sentada y de pie fueron fiables cuando eran realizadas por distintos examinadores o por el mismo examinador en otros días. También se observó que los resultados de las evaluaciones no dependen de la postura empleada.

Palabras clave | Fotogrametría; Postura; Programas Informáticos; Evaluación.

INTRODUCTION

Ideal posture can be defined as a balanced arrangement of body structures, being a state of musculoskeletal balance that preserves the supporting structures of the body against injuries or deformities in the different positions[1]. A normal postural alignment is the one in which muscles and joints are in a state of balance with a minimal amount of effort and overload[1-4]. The preservation of an inadequate posture may lead to pain and functional changes[5], and the anteriorized head posture is one of the most frequent postural changes in this region and may be associated with complaints of pain[5,6].

There are several methods for performing static posture assessment: qualitative methods, such as visual observation; and quantitative methods, such as photogrammetry. In the latter, images can be analyzed by specific softwares[7,8], such as the Postural Assessment Software (PAS), which is considered a practical tool that standardizes measures, besides comparing studies[9].

Despite the growing number of studies that use photogrammetry[10,11], no reference values were found about the angles used to verify certain postural changes, such as anteriorization and inclination of the head, apart from very few studies that verify the reliability and reproducibility of programs used in the postural evaluation[9]. Postural evaluation of the head can be performed in both sitting and standing positions, but studies to evaluate the intra- and inter-examiner reliability of the head positioning assessment and to verify the differences in the assessment results in both positions are still scarce. In this sense, to verify the repeatability of postural angle measures becomes fundamental to control margins of errors, thereby allowing a trustful measure[13].

The objective of this study was to verify the reliability of the intra- and inter-examiner evaluation of anteriorization and inclination angles of the head in the anterior and lateral views on sitting and standing positions, as well as to verify if the measurements depend on the position used. We believe that the measures of anteriorization and inclination angles of the head will be consistent in both intra- inter-examiner evaluations, as well as independent of variation in position.

METHODOLOGY

Ethical considerations

This study was approved by the Ethics and Research Committee of Universidade Paulista under opinion No. 1,063,870 in 2015 and presented a descriptive, quantitative and cross-sectional approach.

Casuistry

Scholars and professors of undergraduate courses in Physical Therapy, Physical Education, Nursing and Nutrition from a college in Southern Brazil participated in the study. The sample was composed of 100 subjects of both genders, aged between 18-35 years old.

The inclusion criteria were: undergraduate students aged 18 to 35 years old, without report of pain or change in the cervical spine and with *Neck Disability Index* questionnaire result (NDI) lower than 5 or 10%.

Exclusion criteria were: presence of diagnosed cervical changes, previous treatment (surgery or not) or history of trauma in the cervical spine region, dysfunction in the shoulder and temporomandibular joint, presence of neck pain in the last 6 months or presence of pain in the cervical region with scores higher than or equal to 5 points or 10% according to the NDI on the day of the assessment, in addition to neurological or psychiatric diseases that could prevent the understanding of the questionnaire.

Instruments

The Postural Assessment Software (PAS) was used to evaluate the head alignment, and also the NDI was applied for the evaluation of disability and pain in the cervical region and a form for subject characterization previously elaborated by researchers, which contained information regarding personal data, presence of some diseases and physical activity practice.

PAS is a free computer program based on marking and scanning of spatially defined points, corresponding to anatomical references about the subject's body[14,15]. Braz et al.[16] evaluated the reliability intra- and inter-examiner and the validity of angular measurements by PAS, which proved to be a reliable and valid alternative to perform angular measurements on body segments.

NDI is a questionnaire with 10 items, designed to assess the disability and pain in the cervical spine region, being adapted and validated for the Portuguese language by Cook et al.[17]. The alternatives, numbered from 0 to 5, describe increasing degrees of cervical pain interference on the performance of the questioned activity. Calculation of scores is obtained by summing the points and subsequent conversion of the result to a percentage value, considering only the items answered by the individual. A score from 0 to 4 (0-8%) indicates no cervical dysfunction; from 5 to 14 (10-28%), mild dysfunction; from 15 to 24 (30-48%), moderate dysfunction; from 25 to 34 (50-64%), severe dysfunction, and from 35 to 50 (70-100%) complete dysfunction[17,18].

Procedures

Initially, subjects were clarified about the overall objectives of the study and collection procedures and requested to sign the Informed Consent Form (ICF), in addition to the authorization for use of the images for academic purposes.

At the moment of evaluation, placemarks (styrofoam balls) were positioned in the following anatomical points: right and left tragi; right acromion and seventh cervical vertebra (C7). A camera (PANASONIC DMC – FH10®) was placed on a tripod 95 cm high and a plumb line was fixed on the ceiling as vertical reference. Two styrofoam balls were put on this line with a 1 m-distance between them, which served as calibration system. The subject and the plumb line were positioned in a plane perpendicular to the camera axis and 3 m distant from it[11].

Evaluation of anteriorization and inclination angles of the head was performed in sitting and standing positions, and the evaluation order was made through random draw. To assess the standing position, the subject's feet were arranged in parallel and neutral position, 10 cm distant from each other, and this distance was measured with a ruler and marked on the ground[19]. For sitting position evaluation, subjects remained in a chair patterned by height (46 cm), width (42 cm) and size of the backrest (27 × 37cm), and were told to keep their back supported by the back of the chair and their feet

touching the floor. The digital images were acquired in the right anterior and lateral views[16]. Both marking of points and obtainment of images were always made by two previously trained evaluators, and each evaluator performed the same function during all collections. On the day of assessment, subjects were wearing bathing suits, had bare feet and, when necessary, tied hair.

After the photographs were taken, they were transferred to the computer, and then delivered to other three evaluators, already familiar with the software PAS, for photogrammetry analysis of the anterior and inclination angles of the head. Two evaluators were undergraduate students of the Physical Therapy course and three were physical therapists with 3 – 7 years of professional experience, and all had at least one year of experience in the use of PAS.

For data analysis in the PAS, the images were scanned and calibrated according to the software protocol; this process was repeated by each evaluator with a one-week interval in order to check their reliability[9], and the order of evaluation between sitting and standing positions was made through random draw.

The variables analyzed were: in the anterior view, (1) the horizontal head alignment angle (HHA_A), formed between both tragi and the horizontal. Positive angle indicates head inclined to the right. In lateral view, the following were analyzed: (2) the horizontal head alignment angle (HHA_L), formed among the tragus, the C7 and the horizontal, indicating that the greater the anteriorization of head, the smaller the angle value; (3) the vertical head alignment angle (VHA_L), formed among the tragus, the acromion and the vertical, with a greater angle indicating greater anteriorization of the head (Figure 1).

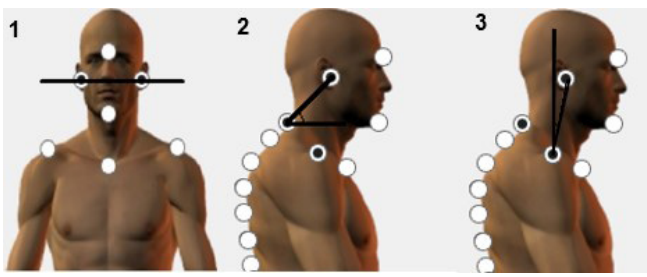

Figure 1. (1) Horizontal head alignment in anterior view (HHA_A); (2); head horizontal alignment in lateral view (HHA_L); (3) Vertical head alignment in the lateral view (VHA_L). Source: SAPO, 2015.

Statistical Analysis

Statistical analysis was performed using the software SPSS v.20.0 (Statistical Package for the Social Sciences). Descriptive statistics was used to characterize the subjects and angle values. Data are presented on average, standard deviation and 95% confidence interval. The Kolmogorov-Smirnov test showed Gaussian distribution of the data. Paired t-test was used to compare differences in the angular values between sitting and standing positions.

The Intraclass Correlation Coefficient (ICC) was applied to verify the inter- and intra-examiner reliability. Reliability studies report that ICC above 0.7 is used as threshold of "sufficiently reproducible." ICC values below 0.70 are considered unacceptable; between 0.71 and 0.79, acceptable; between 0.80 and 0.89, very good; and above 0.90, excellent[20-22].

Additionally, the Bland Altman analysis was carried out to evaluate the correlation between the two evaluations (EV1 and EV2) of each evaluator, for every angle in every position, standing and sitting, in order to show the bias, the error, and the presence of outliers. The significance level adopted was $p \leq 0.05$.

RESULTS

Of 100 subjects assessed, 78 met the inclusion criteria and had the photos analyzed (15 men and 63 women), 22 were excluded by score higher than or equal to 5 in the questionnaire *Neck Disability Index* (NDI). The average age of subjects included in the study was 25.3 ± 5.8 years old, the height was 166.5 ± 8.2 cm and body mass of 63.7 ± 10. 3 kg.

Table 1 shows the values for ICC. The level of inter-examiner reliability and reproducibility has been confirmed by the ICC: of the six angles evaluated, three were classified as excellent, one as very good, one as acceptable and only one as unacceptable. As for the level of intra-examiner reliability, the ICC was classified as excellent in 10 evaluations, as very good in six of them, as acceptable in one, and as unacceptable in only one.

The *Bland Altman* analysis demonstrates the difference and the average between the first and the second evaluation of each evaluator (A, B and C) to the HHA_A (Figure 2), HHA_L (Figure 3) and VHA_L (Figure 4). Most measurements were distributed

within the acceptable limits of variation, indicating that two evaluations of angular measurements made by the same experienced evaluator with the PAS software tend to produce similar results.

No significant differences were observed in the comparison of HHA_A (p=0.465) between the standing (1.93 ± 1.50; CI 95%: 1.78-2.07) and sitting position (1.90 ± 1.54; CI 95%: 1.76-2.04), as well as the HHA_L (p = 0.306) between the two positions (standing: 49.51 ± 4.74; CI 95%: 48.53-52.42; sitting: 49.26 ± 5.27; CI 95%: 48.78-49.74) and VHA_L (p = 0.575) between standing (10.08 ± 7.27; CI 95%: 9.42-10.74) and sitting positions (9.63 ± 6.30; CI 95%: 9.06-10.20).

Table 1. Intraclass correlation coefficient (ICC) and inter- and intra-examiners reliability level of angular measurements in the anterior and lateral views, in the standing and sitting positions.

Inter-examiner angular measurements					
Position	Angles	Evaluator	Angles	ICC	Level
Standing	HHA_A	A	1.96±0.03°	0.875	Very good
		B	1.96±0.06°		
		C	1.93±0.04°		
	HHA_L	A	49.76±0.13°	0.118	Unacceptable
		B	47.15±0.01°		
		C	45.62±0.06°		
	VHA_L	A	10.01±0.04°	0.993	Excellent
		B	9.97±0.19°		
		C	10.26±0.22°		
Sitting	HHA_A	A	1.77±0.01°	0.780	Acceptable
		B	1.82±0.04°		
		C	2.13±0.20°		
	HHA_L	A	49.67±0.30°	0.953	Excellent
		B	48.96±0.23°		
		C	49.35±0.01°		
	VHA_L	A	9.42±0.01°	0.993	Excellent
		B	9.67±0.11°		
		C	9.79±0.06°		
Intra-examiner angular measurements					
Position	**Angles**	**Evaluator**		**ICC**	**Level**
Standing	HHA_A	A		0.890	Very good
		B		0.866	Very good
		C		0.867	Very good
	HHA_L	A		0.029	Unacceptable
		B		0.973	Excellent
		C		0.966	Excellent
	VHA_L	A		0.996	Excellent
		B		0.992	Excellent
		C		0,985	Excellent
Sitting	HHA_A	A		0,888	Very good
		B		0.833	Very good
		C		0.703	Acceptable
	HHA_L	A		0.986	Excellent
		B		0.876	Very good
		C		0.962	Excellent
	VHA_L	A		0.997	Excellent
		B		0.988	Excellent
		C		0.990	Excellent

A, B, C: evaluators; ICC: Intraclass correlation coefficient; HHA_A: horizontal head alignment – anterior view; HHA_L: horizontal head alignment – lateral view; VHA_L: vertical head alignment – lateral view.

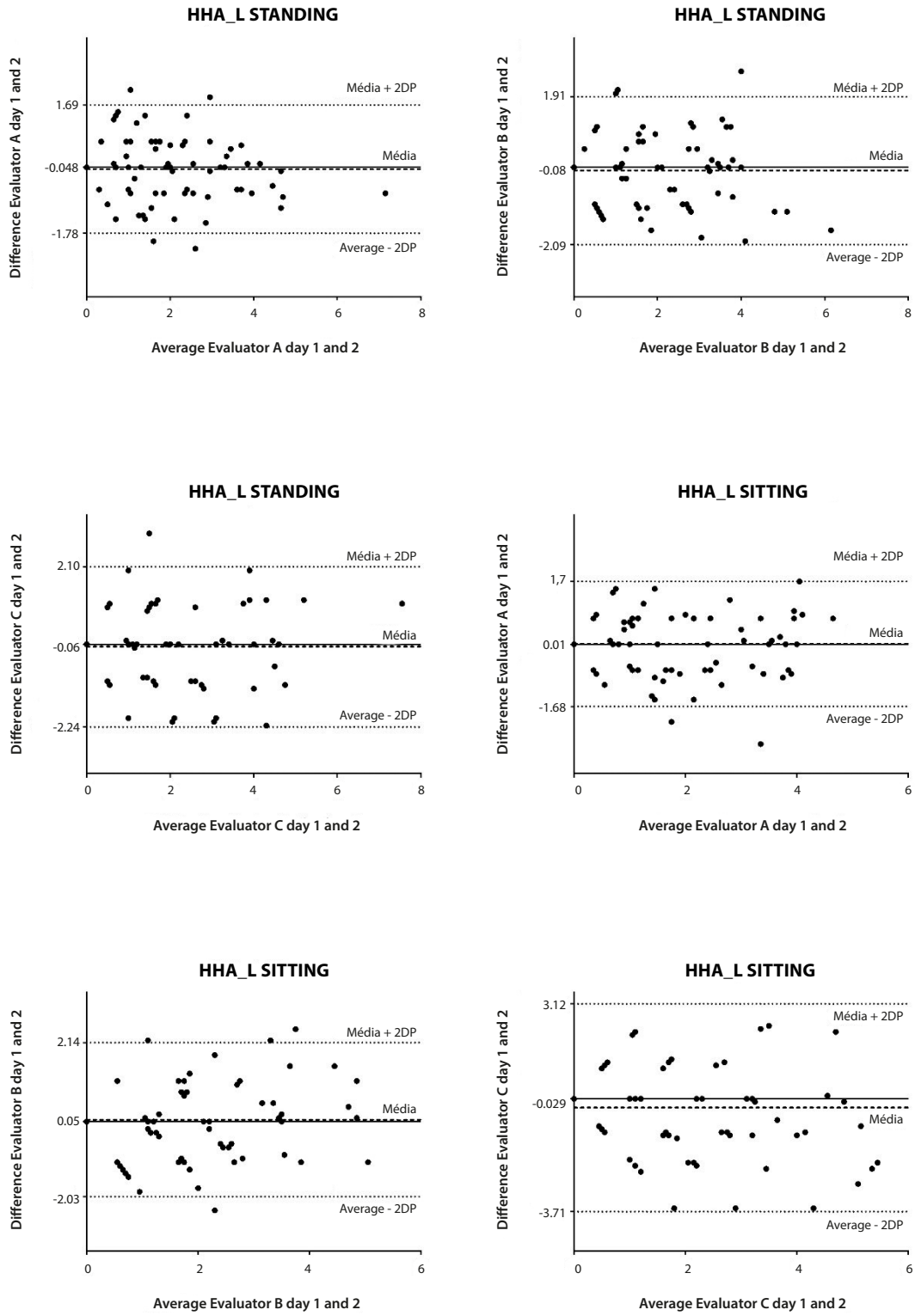

Figure 2. Bland-Altman analysis between the first and the second assessment (AS1 and AS2) of the horizontal head alignment in anterior view (HHA_A) in the evaluators A, B and C, in the standing and sitting positions.

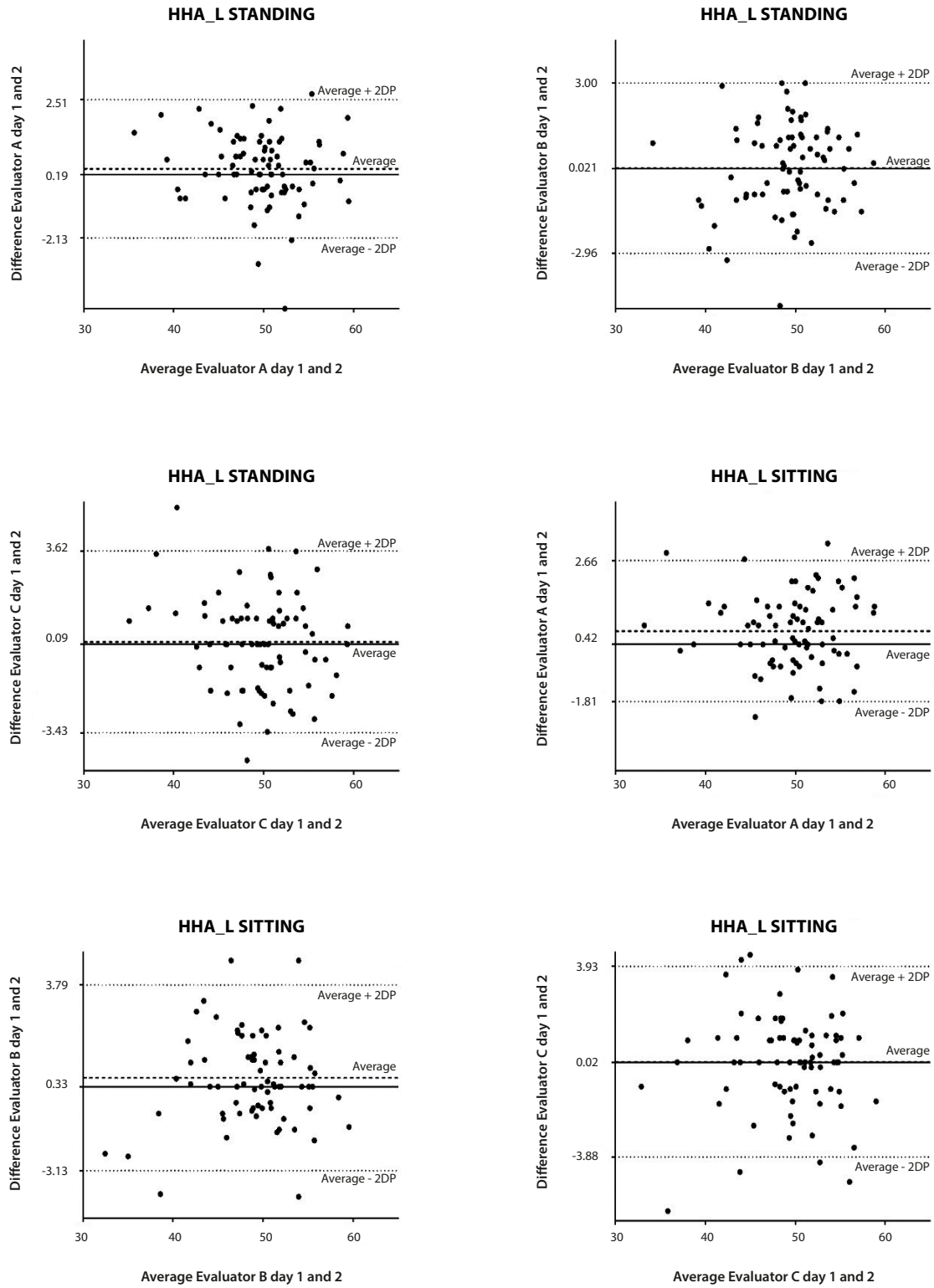

Figure 3. Bland-Altman analysis between the first and the second assessment (AS1 and AS2) of the horizontal head alignment in lateral view (HHA_L) in the evaluators A, B and C, in the standing and sitting positions.

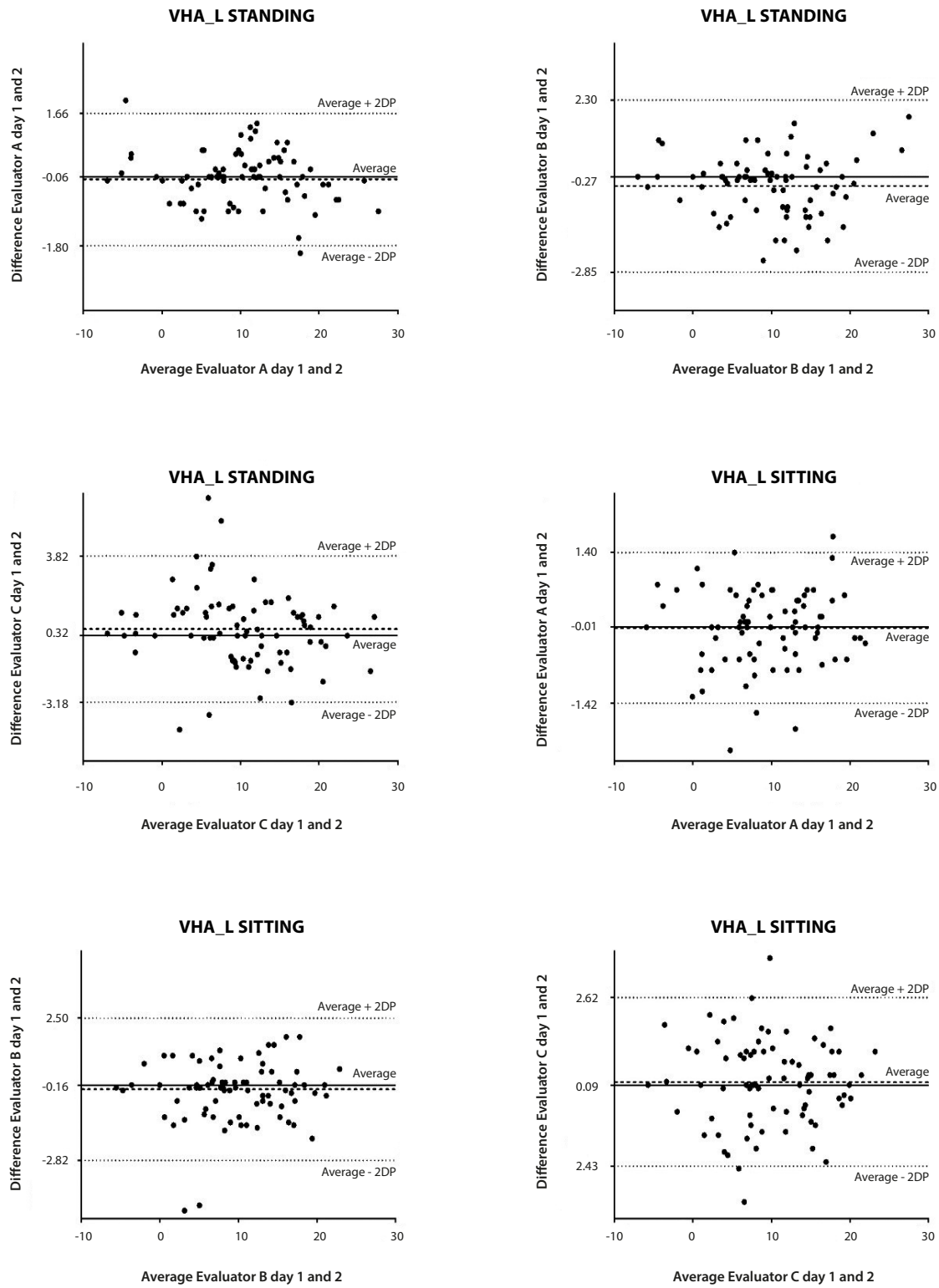

Figure 4. Bland-Altman analysis between the first and the second assessment (AS1 and AS2) of the vertical head alignment in lateral view (VHA_L) in the evaluators A, B and C, in the standing and sitting positions.

DISCUSSION

This study verified the intra- and inter-examiner reliability evaluation of the anteriorization and inclination angles of the head in the anterior and lateral views, in the sitting and standing positions through PAS software.

The results showed repeatability of angular inter-examiners measurements. The three different evaluators presented excellent ICC in three angles (VHA_ – standing; HHA_L – sitting; VHA_L – sitting), very good in one (HHA_A – standing), acceptable in one (HHA_A – sitting) and unacceptable in only one (HHA_L – standing). Corroborating this study, Souza et al.[9], following a similar methodology, observed that of 20 angles evaluated by the PAS Protocol, 16 showed excellent reliability, one acceptable, one very good and just two unacceptable.

Evaluation of posture by photogrammetry has reported excellent[9] and acceptable[21] inter-evaluator reliability indices. Souza et al.[9] observed in the angles concerning the horizontal head alignment (HHA) and vertical head alignment (VHA) in the anterior and lateral views the following results regarding the ICC: in anterior view, for the HHA, ICC 0.949, with excellent reliability, in lateral view for the HHA, ICC 0.987 and excellent reliability level, for VHA, ICC 0.995 and excellent reliability level. Ferreira et al.[21], examined 3 angles that were analyzed in this study. In the anterior view, for the HHA, they obtained ICC 0.716 and acceptable reliability level and in lateral view for the VHA, ICC 0.922 and excellent reliability level.

However, Dunk et al.[23] observed low ICC, which reflected the poor repeatability of evaluations carried out by the photogrammetry in the study when made on the same day and on different days. In this study, only the angle related to the horizontal head alignment in the lateral view presented ICC classified as unacceptable in intra- and inter-examiner analysis and both in the standing position. We believe that this result could be due to examiners' subjective factors at the moment of evaluation. Another hypothesis is that it could have been occasional since the errors inherent to the placing of markers, camera position, among others, were controlled because the same photographic record was used in all analyses.

Lunes et al.[22] and Souza et al.[9] found reliability indices lower in the evaluations carried out in the lateral view in relation to the anterior view, which was also observed in this study. For the authors, these findings may be related to anatomical markers because in this view there is variation in the depth plans recorded in the photographs. However, according to Dunk et al.[23], the sagittal plane is the one that best reflects the postural clinical evolution, since the angular values in this plane are not zero, different from the values found in the frontal plane, in which the symmetry tends to zero. Considering that in this study all other analyses carried out in the lateral view showed levels of very good or excellent reliability, we recommend to use the evaluations in this view for analysis of the head anteriorization.

Dunk et al.[23] claim that bodily oscillations inherent in standing posture can lead to errors in measurements in relation to the vertical position. However, in our research, in comparison with the head alignment in the anterior and lateral views between sitting and standing positions, no significant differences were observed in angular values between the two positions in the various assessments made, demonstrating that the change in body position in these situations did not modify the head alignment.

We have found no studies comparing the head alignment between the two positions. It is possible that there were no changes in the head alignment between the two situations, because the head was not supported in the chair during the sitting assessment, thus suffering the action of gravity as well as in the standing position. In addition, in the sitting assessment, the ICCs of all angles analyzed were classified as acceptable, very good or excellent. Therefore, these results indicate that the assessment of the head alignment in the sitting position proves to be a reliable alternative for the analysis of anteriorization and inclination of the head.

Studies that verify the reliability of the head alignment assessment with the subject in a sitting position are still scarce. Carneiro et al.[24] analyzed the intra- and inter-examiner reliability of the head postural evaluation by photogrammetry using Corel Draw software with the subjects in sitting position. The authors carried out the evaluation only in lateral view, noticing that this method was reliable when performed by the same evaluator; however, in the inter-examiner analysis there was low reliability, which may have occurred, according to the authors, because of reduced experience with the method of one of the evaluators. In this study, all evaluators were experienced with the analysis through the PAS software, which also may

have contributed to the high levels of reliability in the analyses performed.

Through the Bland Altman's analysis, we observed that there was no systematic bias in the agreement of the repeated measurements for the three evaluators. Most measurements were distributed within the acceptable limits of variation, indicating that two evaluations of angular measurements made by the same evaluator tend to produce similar results.

The size of anatomical markers used was considered a limitation of this study because they hampered the marking at the time of scanning for being small. However, it is believed this has not affected the study data since the evaluators used zoom control to enhance the image and facilitate the marking of points.

We suggest future studies comparing the reliability of the head alignment assessment between the photogrammetry, three-dimensional analysis and visual inspection, also observing if differences occur in the results obtained by these three evaluations.

CONCLUSIONS

The results of this study showed good levels of intra- and inter-examiners reliability in evaluation of inclination and anteriorization angles of the head in the anterior and lateral views, both in sitting and standing positions. Additionally, the findings showed the assessment of the head alignment, by means of anteriorization and inclination angles of the head, do not depend on the position used in the assessment, i.e., standing or sitting.

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