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Intra- and inter-examiner reliability of the head postural assessment by computerized photogrammetry

Confiabilidade inter e intraexaminador da avaliação postural da cabeça por fotogrametria computadorizada

Confiabilidad inter e intra-evaluador de la evaluación postural de la cabeza por fotogrametría computarizada

Paula Rossi Carneiro[1], Lídia Cristina da Silva Teles[2], Caroline Modesto da Cunha[3], Bárbara dos Santos Cardoso[4]

ABSTRACT | Scientific articles about reliability of photogrammetry for cervical spine posture evaluation are infrequent. The aim of the present investigation is to verify intra- and inter-examiner reliability of computerized photogrammetry method for head postural evaluation in lateral view. Twenty-five young women between 20 and 30 years old were positioned seated in an upright position and photographed in lateral view. The photographs were imported to Corel Draw X13 program for postural evaluation by computerized photogrammetry. The reliability of intra- and inter-examiner analyses were performed for the angles: condyle-acromion (ACA), menton-sternum (AME) and Frankfurt (AF). The photogrammetry was performed by two examiners: EA and EB. The EA performed analysis of the photos of participants twice (A1 and A2) for the same angles in a range of three months to assess intra-examiner reliability. The EB performed the photogrammetry for the same angles (B1) for comparison with the data from EA (inter-examiner analysis). Excellent correlation in the intra-examiner analysis (A1 and A2) was found for the angles: ACA and AME, both with a 1.0 interclass correlation coefficient (ICC); for the AF angle, it was found ICC=0.78. For the ICC inter-examiner between A1 and B1, it was observed: ACA (ICC=0.24), AME (ICC=0.26), and AF (ICC=0.00). For the comparison between A2 and B1 the ICC values were: 0.23; 0.27; and 0.00, respectively for ACA, AME and AF, classified as weak correlations. The photogrammetry is reliable when performed by the same examiner. The inter-examiner assess showed low reliability, what could have been compromised by the reduced experience of the EB in applying the method.

Keywords | Photogrammetry; Posture; Reproducibility of Results.

RESUMO | A literatura sobre confiabilidade da fotogrametria para avaliação postural cervical é escassa. O objetivo do presente estudo é verificar a confiabilidade intra e interexaminador da fotogrametria computadorizada para avaliação postural da cabeça em vista lateral. Vinte e cinco mulheres jovens foram posicionadas sentadas com a coluna ereta e fotografadas em vista lateral. As fotografias foram importadas pelo programa Corel Draw X3 para avaliação postural por fotogrametria computadorizada. As análises de confiabilidade intra e interexaminadores foram realizadas para os ângulos: côndilo-acrômio (ACA), mento-esternal (AME) e Frankfurt (AF). A fotogrametria foi realizada por dois examinadores: EA e EB. Para a análise intraexaminadores o EA fez a avaliação das fotos das participantes por duas vezes (A1 e A2) para os mesmos ângulos em um intervalo de três meses. Para a análise interexaminadores o EB avaliou a fotogrametria dos mesmos ângulos (B1), que foi comparada com os dados do EA. Houve correlação excelente na análise intraexaminador (A1 e A2) com coeficiente de correlação intraclasse (CCI) de 1,0 para os ângulos ACA e AME e 0,78 para AF. Houve fraca correlação na análise interavaliadores A1 e B1 com CCI=0,24 e 0,26; e entre A2 e B1 com CCI=0,23; 0,27 e 0,00 para os ângulos ACA, AME e AF, respectivamente. Conclui-se que a fotogrametria é confiável quando realizada pelo mesmo avaliador. A avaliação interexaminador apresentou baixa confiabilidade, o que pode ter sido comprometida pela reduzida experiência do EB na aplicação do método.

Descritores | Fotogrametria; Postura; Reprodutibilidade dos Testes.

Study conducted at the Voice Laboratory at the Speech Therapy Clinic at the School of Odontology of Bauru, Universidade de São Paulo (USP) – Bauru (SP), Brazil.
[1]Bioengineering Interunits at USP – São Carlos (SP), Brazil.
[2]Department of Speech Therapy, School of Odontology of Bauru, USP – Bauru (SP), Brazil.
[3]Universidade Federal de São Carlos (UFSCar) – São Carlos (SP), Brazil.
[4]Faculdade Anhanguera de Bauru – Bauru (SP), Brazil.

Correspondence to: Paula Rossi Carneiro – Avenida Nossa Senhora de Fátima, 4-86, apto. 10 – Jardim Paulista – CEP: 17017-337 – Bauru (SP), Brazil – E-mail: prossic@hotmail.com
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RESUMEN | La literatura acerca de la fiabilidad de la fotogrametría para la evaluación postural cervical es escasa. El objetivo de este estudio es verificar la fiabilidad intra e interexaminador de la fotogrametría computadorizada para la evaluación postural de la cabeza en vista lateral. Veinticinco mujeres jóvenes fueron posicionadas sentadas con la espalda recta, y fotografiadas en vista lateral. Las fotografías fueron importadas por el programa Corel Draw X3 para la evaluación postural mediante fotogrametría computadorizada. Los análisis de fiabilidad intra e interexaminadores se realizaron para los ángulos: cóndilo acromion (ACA),mentoesternal (AME) y Frankfurt (AF). La fotogrametría fue realizada por dos examinadores: EA y EB. Para el análisis intraexaminadores el EA hizo la evaluación de las fotos de las participantes por dos veces (A1 y A2) para los mismos ángulos en un intervalo de tres meses. Para el análisis interexaminadores el EB evaluó la fotogrametría de los mismos ángulos (B1) y se la comparó con los datos del EA. Hubo una excelente correlación en el análisis intraexaminador (A1 y A2) con coeficiente de correlación intraclase (ICC) de 1,0 para los ángulos ACA y AME y 0,78 para AF. Hubo débil correlación en el análisis intereva-luadores A1 y B1 con ICC=0,24 y 0,26; y entre A2 y B1 con ICC=0,23; 0,27 y 0,00 para los ángulos ACA, AME y AF, respectivamente. Se concluye que la fotogrametría es fiable cuando se realiza por el mismo evaluador. La evaluación interexaminador mostró baja fiabilidad, lo que puede haber sido comprometida por la limitada experiencia de EB en la aplicación del método.

Palabras clave | Fotogrametría; Postura; Reproducibilidad de Resultados.

INTRODUCTION

Everybody desires a good bodily posture. In good posture, all joints supporting one's height are aligned for the minimum overload for muscles and ligaments[1-4]. Bad bodily alignment may impair load distribution, thus increasing pressure on joint surfaces and favoring joint degeneration and muscular tensions[3,5]. Tensions in the cervical area may cause changes in head and neck posture such as neck angle anteriorization, posteriorization, lateralization[3].

In order to assess posture asymmetries and prevent worsening and progression of certain neck dysfunctions, posture assessment is required as physical therapy routine to identify misalignments and structural or functional changes, so that proper management and treatment can be established for posture realignment[6,7].

The main tool used to assess posture is visual analysis[8,9], which can be aided by photos.

Photography as image documentation helps in clinical practice and scientific studies once it allows measurement of results, therefore, objective and accurate analysis.

In the medical area, Kvedar *et al*.[10] stated that digital photographic image may replace skin examination in up to 83% of cases. That requires a standardization of the environment and camera positioning in order to register images without any distortion and with sharpness[11,12]. Computerized photogrammetry is one of the methods used for posture assessment. Body angles are measured by means of photographic records[13], enabling a quantified assessment[2,6,14,15]. Quantification may be done in software such as CorelDraw, AutoCAD or SAPo[6,16], which makes files' storing easier and saves space and time while accessing images[16], not to mention low cost[17-19]. This tool has been proven reliable for many posture assessments, as reported in some studies. Baraúna *et al*.[20] studied static balance of transfemoral and transtibial amputees; Lima *et al*.[21] identified posture changes in mouth breather children; Manfio *et al*.[22] assessed the posture of women wearing high-heel shoes and flats, and barefooted; Caetano e Nicolau[23] evaluated postural correction after bodily awareness and self-stretching. Due to the rapid diffusion of photogrammetry, several studies were conducted to assess reliability and validity of this technique as a tool for postural assessment[2,24] by consistency or agreement of results. However, the literature on the subject related to cervical posture is poor. We found no studies on the reliability of protogrammetry regarding specific angles to assess head anteriorization and posteriorization, or lateral view of cervical flexion or extension. The reliability of a method is tested by comparing results of examinations performed by different examiners (inter-examiner) for the same subjects, and by comparing results of subjects assessed by the same examiners (intra-examiner)[2]. Therefore, the aim of this study was to verify intra and inter-examiner reliability of computerized protogrammetry for the assessment of head posture in lateral view.

METHODOLOGY

Ethical considerations

The study was initiated after approval by the Reearch Ethics Committee of Universidade de São Paulo. All participants were informed of the study purposes and procedures, and in agreeing with it, they signed the informed consent form.

Casuistry

Twenty-five women aging 20 to 30 years (mean age 23.32±2.59) participated in the study. Inclusion criteria were: not presenting relevant postural changes such as thoracic hyperkyphosis, cervical hyperlordosis, scoliosis, exacerbated shoulder and head protrusions, and not presenting musculoskeletal disorders of the trunk, head and neck, including muscle tension, contractures (cramping), weakness and/or pain in these regions. These data were collected upon a classical posture evaluation performed by the main author of this paper and with the use of a questionnaire fulfilled by participants. Sample loss did not occur in our study.

Procedures

For data collection, an evaluation form fulfilled with subjects' name and age, also containing a table for photogrammetry data. Participants remained in sitting and standing position and were asked to perform head anteriorization and posteriorization, and cervical spine flexion and extension. Evaluations were performed in sitting position because this is often a position that causes damages to the spine — especially cervical spine —, even more than standing position, and because countless professionals work all day long at a desk/computer[13,25].

Anatomical landmarks were indicated on the subjects' skin using round adhesive markers (Pimaco) measuring 9 mm in diameter: mandibular condyle, acromion of scapula, and xiphoid process of sternum.

Participants were photographed in left lateral view with use of a camera (Sony, cybershot DSC-P200 7.2 Megapixels) on a supporting tripod 1.0 m high and 1.5 m distant from the chair where the subjects were sitting. Images were then imported into Corel Draw X3 for computerized photogrammetry.

Three angles related to head and neck positioning were then marked and investigated from the lateral view, based on previously marked anatomical landmarks. Angles studied were[18]:

- condyle-acromion angle (CAA): formed by the joining of landmarks of mandibular condyle and acromion of scapula to a line at right angles to the ground;
- mentosternal angle (MSA): formed by intersection of the line formed by the joining of the most anterior portion of the chin, not marked because it is easily seen laterally, to the xiphoid process on the line at right angles to the ground;
- Frankfurt angle (FA): formed by intersection of the Frankfurt plane with the line at right angles to the ground. Frankfurt plane is a line formed by the joining of landmarks not marked because they are easily seen laterally: external auditory meatus and inferior orbital fissure[26].

These angles were adopted because, they show head positions in lateral view. FA shows changes in head flexion and extension, while CAA and MSA show head anteriorization and posteriorization.

Photogrammetry was performed by two examiners: examiner A (EA) and examiner B (EB). In intra-examiner analysis, EA assessed photos of the participants twice (A1 and A2) for the same angles with an interval of three months. In inter-examiner analysis, the photos were sent to EB, as this examiner had performed photogrammetry of the same angles to further comparison with EA's data. Both examiners assessed all angles of all subjects.

As to examiner training, EA had two years of experience in computerized photogrammetry for posture assessment at the moment of study. EB had been trained for three weeks — seven days, three-hour sessions — in order to use photogrammetry.

Statistical analysis

Statistical analysis was made in the software BioEstat 5.0, using intraclass correlation coefficient (ICC) of 1.1[27] — continuous data — for samples in both intra- and inter-examiner analyses. Weak correlation was that with values below 0.4; satisfactory correlation was ≥0.4 and <0.75; excellent correlation was values ≥0.75[28].

RESULTS

The results of photogrammetry for CAA, obtained by examiner A in the first and second analyses (A1 and A2)

and by examiner B (B1), as well as intra- and inter-examiner results by ICC are shown in Table 1.

Mean MSA in the analyses by examiner A (A1 and A2) and examiner B (B1), along with statistical comparisons of ICC test for both intra- and inter-examiner analyses are found in Table 2.

The results of FA photogrammetry by examiner A (A1 and A2) and examiner B (B1), and intra- and inter-examiner statistical analyses with ICC are presented in Table 3.

DISCUSSION

In this study, intra- and inter-examiner reliability of photogrametry in head and cervical spine posture was made by evaluating women in sitting position. McEvoy and Grimmer[13] emphasize the interest bodily posture in sitting position, once this position is adopted by people working constantly at screens and may lead to musculoskeletal disorders, with consequent loss of productivity.

Analyses were restricted to lateral view, once it allows better perception of head anteriorization and posteriorization. Posture analysis from lateral view has been performed by Carneiro and Teles[18] aiming at head anteriorization. From anterior view, Pasinato *et al*.[29] assessed the lateral angle of inclination of the head in patients with and without temporomandibular dysfunction, and evaluated a vertical angle showing head anteriorization or posteriorization. In this study, we used CorelDraw X3 to analyze photogrammetry. Reliability of Corel Draw, AutoCAD and SAPo regarding photogrammetry has been assessed in studies by Sacco *et al*.[16] and Guariglia *et al*.[30], who concluded they are reliable for this purpose. Repeatability of the method has been tested by Carneiro e Teles[18] using Corel Draw 10 to analyze nine cervical spine and trunk angles from lateral view in one subject for 25 non-consecutive days. They concluded that this method is reliable for eight of the angles studied.

Regarding head positioning in lateral view, reliability was show to be excellent in intra-examiner analysis and weak in inter-examiner analyses. Similar results were found by Fedorak *et al*.[31], who assessed reliability

Table 1. Mean values of condyle-acromion angle in photogrammetry performed by examiner A (A1 and A2) and examiner B (B1), and intraclass correlation coefficient values for intra- and inter-examiner analyses

	Condyle-acromion angle				Intraclass correlation coefficient		
	A1	A2	B1	Comparison	A1 x A2	A1 x B1	A2 x B1
Mean value	25.84º	26º	22.56º	Result	1.00	0.24	0.23
Standard deviation	7.60	7.65	4.51	Correlation	excellent	weak	weak

Table 2. Mean values of mentosternal angle in photogrammetry performed by examiner A (A1 and A2) and examiner B (B1), and intraclass correlation coefficient values for intra- and inter-examiner analyses

	Mentosternal angle				Intraclass correlation coefficient		
	A1	A2	B1	Comparison	A1 x A2	A1 x B1	A2 x B1
Mean value	-0.68º	-0.24º	-1.80º	Result	1.00	0.26	0.27
Standard deviation	8.15	7.48	5.18	Correlation	excellent	weak	weak

Table 3. Mean values of Frankfurt angle in photogrammetry performed by examiner A (A1 and A2) and examiner B (B1), and intraclass correlation coefficient values for intra- and inter-examiner analyses

	Frankfurt angle				Intraclass correlation coefficient		
	A1	A2	B1	Comparison	A1 x A2	A1 x B1	A2 x B1
Mean value	89.84º	88.96º	80.00º	Result	0.78	0.00	0.00
Standard deviation	6.60	4.60	6.88	Correlation	excellent	weak	weak

of postural assessment using photographs. However, other studies point out acceptable levels of reliability for both intra- and inter-examiner assessments. Iunes *et al.*[6] performed a study on 22 angles assessed by two examiners, where 17 showed high reliability levels and 5 showed reliability below acceptable levels, being concluded that the method is significantly reliable. Other studies have reported excellent results of reliability of computerized photogrammetry in intra- and inter-examiner analyses[32,33]. Santos *et al.*[24] described 80% agreement between 3 examiners in photogrammetry recordings of 122 children submitted to only one photo record for postural assessment in anterior frontal, posterior, left and right sagittal views. The authors pointed that examiners had been trained in a previous study, which guaranteed high reliability.

Low reliabilty in inter-examiner analysis found in our study may be related to the professional background of EA compared to first contact of EB with computerized photogrammetry in a seven-day training program before the study. Although photogrammetry is performed in marked anatomical landmarks, the assessment of body angles depends on the examiner's practice, which draws attention to the importance of professional training in posture assessment. The literature lacks studies that guide professionals as to adequate type and time of training in order to assess posture by photogrammetry.

CONCLUSION

Reliability of computerized photogrammetry is good for intra-examiner assessment of head position angles, but weak for inter-examiner assessments. This inter-examiner weak reliability may indicate the need for examiners training, which is fundamental for the credibility of clinical physical therapy and rehabilitation research.

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