

Craniocervical posture: cephalometric and biophotogrammetric analysis

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Abstract

Aim: To investigate the correlation between the craniocervical posture measurements obtained by the biophotogrammetric and cephalometric analysis. **Methods:** 80 women aged between 19 and 35 years were evaluated by the cephalometric and biophotogrammetric methods. The cephalometric variables were: CVA (position of flexion/extension of the head) CPL (forward head posture) CVT/EVT ratio (cervical column curvature). For the biophotogrammetric analysis, photography were analyzed in right profile being two angles related to the head forward posture (A1 and A2) and one related to flexion-extension head position (FE). It was also measured the curvature of the cervical spine by the cervical distance. The correlation between the craniocervical posture variables, as measured by the two methods of assessment, was analyzed by the Pearson's correlation with a significance level of 5%. **Results:** It was observed a moderate and significant agreement ($p=0.00$) between the postural craniocervical variables that analyzed the flexion-extension head position (FE and CVA) and the forward head (CPL and A1). The evaluation of the cervical curvature by the DC measure showed no correlation with the cephalometric variable CVT/EVT. **Conclusions:** The biophotogrammetric analysis can be preferably chosen for assessing the head posture. However, the cephalometric analysis appears to be the most indicated for the cervical curvature measurement, since it enables a more objective view of the bone structures without the influence of the soft tissues.

Keywords: evaluation, posture, cephalometry, photogrammetry.

Introduction

The applicability and the methods of craniocervical postural analysis have been investigated in the literature in a multidisciplinary way, basically by experts in the field of Physical Therapy, Dentistry and Speech Therapy. There are several procedures that serve as an aid to craniocervical postural analysis, being three of them considered more popular¹.

The classic method is based on visual analysis, using qualitative observations of postural asymmetries, having as a reference pattern the model proposed by Kendall² (1995). Regardless of the examiner's experience, this type of measure is considered of less credibility in relation to quantitative measures³.

The second proposed method, the biophotogrammetry, stands out because it represents a simple, noninvasive and low-cost method. It consists in the analysis of angles and linear measurements of points marked on the skin in some of the

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individual body segments. Such measures can be viewed and interpreted in digital photographic records. With the advancement of technology is considered the most requested method by professionals who perform postural assessment, both for investigative slant as to aid in the clinical diagnosis and in the therapeutic approach⁴. Moreover, the great advantage of biophotogrammetry is to allow changes in craniocervical posture to be quantified and small changes to be detected⁵.

Currently, the most accurate craniocervical postural analysis method is the cephalometry, in which it is used the lateral radiograph of the skull and of the cervical spine to perform cephalometric measurements. By means of the radiography, it is possible a more objective visualization of the craniocervicomandibular structures, without the influence of soft tissues, as occurs in the biophotogrammetry¹. However, cephalometric analysis has little impact on clinical practice because the limitation of its applicability is related to high costs and technique complexity⁶.

Recent studies have sought to investigate the correlation between measurements of posture, obtained by biophotogrammetry and by visual analysis^{3,5}. On the other hand, there are few studies investigating the correlation between the findings obtained by the biophotogrammetric and cephalometric analyses.

Considering the increasing number of studies using the biophotogrammetric analysis, because of the easy access to it in the clinical practice, it is necessary to develop studies to verify the agreement of the photographic method of the postural analysis with the radiographic method, which is more objective, but more expensive and with the individual's exposure to radiation. In other words, are biophotogrammetric measures related to head posture and does the cervical spine reflect the postural changes observed in the cephalometric analysis?

For its interdisciplinary approach, it is believed that this research is of interest to dentists, physical therapists, speech therapists and other professionals since it may assist them in the reflection of their clinical practice and in the context of scientific research.

Material and methods

Eighty women with mean age of 23.8 ± 3.65 years (19-35 years) and BMI of 22.4 ± 3.83 kg/cm² recruited voluntarily through the print media participated in this study.

This research project was approved by the Ethics Committee in Health Research under the number 0048.0.243.000-08, recognized by the National Research Ethics (CONEP). All individuals who participated in the study were included by accepting and signing a free informed consent form.

The exclusion criteria of the study were: history of facial and/or craniocervical trauma, presence of acute and severe musculoskeletal pain, musculoskeletal deformities (scoliosis, congenital bone malformation), craniomandibular orthopedic

surgical procedures and/or neck, and a previous diagnosis of cervical disc herniation.

Biophotogrammetric evaluation

The posture of the head and of the cervical spine was evaluated by means of digital photograph, with biophotogrammetric analysis by the postural assessment software (SAPO®). Pictures were taken in standing position in right lateral view.

Anatomic points were marked in the subject's body with white Styrofoam balls wrapped in reflective tape and previously prepared with double-sided tape for attachment to the skin. During the image acquisition, the volunteers were oriented to keep the usual body posture with opened eyes glancing to the horizon line.

The participants with suitable clothing, hair tied back and barefoot were photographed in a scenario constituted by a black background of 3x1.5 meters, a plumb line suspended in the roof beside the volunteer, a base with 10x40x20 centimeters of dimensions with the foot outline drawn in a rubber rug. A tripod (Vanguard® - VT 131) was positioned at a distance of, at least, 3 meters from the digital camera (Sony® Cybershot 7.2 megapixels) and in a 1.20 meter height from the floor. In order to reproduce the natural position of the head, the individual was instructed to look at the reflection of his eyes in a mirror positioned at one meter of distance⁷⁻¹⁰.

Four variables related to the craniocervical posture were evaluated (Figure 1). Three angles measured the position of the head, being two related to the forward head posture: A1 - angle formed between the tragus, spinous process of the seventh cervical vertebra (vertex) with the horizontal¹¹⁻¹² and A2 - angle formed between the external acoustic meatus (vertex), chin and sternal notch¹². The third angle was related to the flexion-extension head position (FE) and it was formed by the points marked in the spinous process of the seventh cervical vertebra, tragus (vertex) and palpebral commissure¹¹. The smaller the A1 angle and the greater the A2 angle, the more forward the head. Regarding the FE, the greater the angle, the greater the hyperextension of the head on the upper cervical spine.

The curvature of the cervical spine was measured by the horizontal distance from a vertical line tangent, by the apex of the thoracic kyphosis, called as thoracic plan, and by the point of the apex of the cervical concavity¹³.

With a one-week interval, the images of 20 individuals were randomly assigned to a second analysis of the variables to verify the intra-examiner reliability of the measurements.

Cephalometric evaluation

Subjects underwent a right lateral radiograph of the skull and of the cervical spine in a normal standing position, thus preserving the true resting position of the head and of the cervical spine. The posture adopted by the individual in the cephalometric evaluation of the right profile was the same as required for the acquisition of the photographic record, so that the natural position of the head was also reproduced.



Fig. 1 – Craniocervical biophotogrammetric variables A) Angle FE – head flexion/extension of B) Angle A1 – Forward head posture; C) Angle A2 – Forward head posture

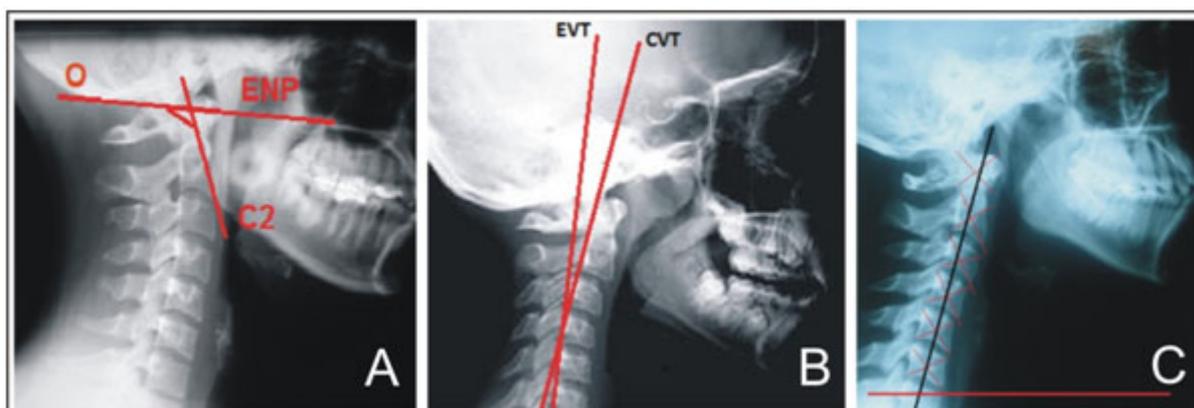


Fig. 2 – Craniocervical cephalometric variables. A) craniovertebral angle (CVT); B) CVT/EVT Angle – Cervical lordosis; C) CPL/HOR angle– Forward head posture.

The cephalometric radiography to assess the craniocervical posture was performed with the Orthophos Plus equipment (Siemens, Erlangen, Germany) with the chassis positioned parallel to the face and immediately adjacent to the shoulder of the individual to ensure the visualization of C7. It was used chassis with T MAT G Kodak film of de 18x24 cm, with a fixed focus distance of 1.52 m and in accordance with the protocol of radiation protection in accordance with Ordinance 453 of 06/01/1998 (Ministry of Health, Department of Health Surveillance).

All angles were traced manually by a single, previously trained examiner. The cephalograms were drawn on acetate paper with the aid of a mechanical pencil (graphite 0.3 mm) using a light box in order to enable a better visualization of the structures. A protractor to perform the angular measurements and a millimeter ruler for the linear measurements were used.

In the lateral radiographic record, three variables related to the posture of the head and of the cervical spine (Figure 2) were evaluated. The position of flexion/extension of the head was measured using the cranio-vertebral angle of Rocabado¹³ (1983), recently described in the literature^{3,14-15}. This angle is formed by the McGregor Plane (a plane that touches the base of the occipital bone to reach the posterior nasal spine) and by the odontoid process (from the apex of the odontoid process of C2 to the most anterior and inferior

point of the body of C2). The smaller the CPL-Hor angle, the greater the hyperextension of the head on the upper cervical spine.

The forward head posture was measured by the angle formed by the intersection of the CPL line (craniocervical postural line) in relation to the horizontal⁸. The CPL line reaches the central points that are demarked in the body of the first six cervical vertebrae. The smaller the CPL-Hor angle, the more forward the head.

For the analysis of the cervical curve the CVT/EVT ratio was used¹⁵⁻¹⁶. The CVT line intersects the apex of the tooth of the second cervical vertebra with the most posterior-inferior point of the body of the fourth cervical vertebra, while the EVT line intersects the most posterior-inferior points of the body of the fourth and sixth cervical vertebrae. The smaller the CVT/EVT angle, the more rectified the cervical curvature.

The variables were measured by a single examiner through manual cephalometric tracing. With a one week interval, 20 radiographs were randomly assigned to a second analysis of the variables to verify the reliability of the performed tracing.

Statistical analysis

The Intraclass correlation coefficient (ICC) verifies the reliability of the cephalometric measurements. The ICC values should be greater than 0.75 to indicate good reliability and

Table 1 – Intra-examiner reliability of cephalometric and biophotogrammetric variables

Cephalometric variables	ICC	Confidence interval	p
CVT/EVT	0.979	0.947 – 0.992	*0.000
CVA	0.995	0.987 – 0.998	
CPL	0.901	0.754 – 0.960	
Biophotogrammetric variables			
FE	0.976	0.941 – 0.990	*0.000
A1	0.978	0.946 – 0.991	
A2	0.997	0.993 – 0.999	
DC	0.974	0.936 – 0.989	

CVA: craniovertebral angle related to the flexion/extension head position; CVT/EVT cervical curvature ratio; CPL: angle related to the position of forward head posture, FE: angle related to the flexion/extension head position, A1: angle related to the forward head posture with vertex at the seventh cervical vertebra, A2: angle related to the forward head posture with vertex in the external acoustic meatus, DC: cervical distance.

those below 0.75 indicate poor to moderate reliability¹⁷.

A descriptive analysis of the demographic variables of age, weight, height and BMI was performed. Additionally, we analyzed the correlation between variables related to craniocervical posture measured by cephalometry and by biophotogrammetry as well as the correlation between postural variables measured by the two methods of evaluation. For this purpose, the Pearson's coefficient was used ranging from -1 (negative correlation, variables vary in opposite direction) to 1 (positive correlation, variables vary in the same direction). The correlation was considered strong for values of correlation coefficient (r) greater or equal than 0.7, moderate when $0.3 < r < 0.7$, and weak when $0 < r < 0.3$ ¹⁸. Analysis were performed using the STATISTICA 7.1 (StatSoft Inc., Tulsa, OK, USA) and SPSS 17.0 (SPSS Inc., Chicago, IL, USA) softwares and a significance level of 5% was considered.

Results

Results of the ICC showed excellent levels of reliability for all measurements in the biophotogrammetric and cephalometric analyses by the same examiner at two different times (Table 1).

Correlations between biophotogrammetric and cephalometric variables tested separately for each method are presented in Table 2.

Table 3 shows the values related to the correlation between the two assessment methods of craniocervical posture. It was observed a moderate and significant agreement ($p=0.00$) between the craniocervical postural variables that measured the head flexion-extension position (CVA and FE) and the forward head posture (CPL and A1).

Discussion

The computerized biophotogrammetry is considered a reliable and reproducible method being an important tool in the evaluation of body posture^{3,19}. High values of ICC for the craniocervical postural variables measured by means of the manual cephalometric tracing have been demonstrated²⁰, corroborating the excellent levels of reliability for all drawing

Table 2 - Correlation between the different craniocervical postures evaluated in each method

Biophotogrammetric variables	r	p
A1 x A2	-0.21	0.05
A1 x FE	-0.62	0.00**
A2 x FE	0.23	0.01**
A1 x DC	-0.68	0.00**
A2 x DC	0.11	0.21
DC x FE	0.38	0.00**
Cephalometric variables		
CVA x CPL	0.61	0.00*
EVT/CVT x CVA	0.33	0.06
EVT/CVT x CPL	0.15	0.11

A1: angle related to the forward head posture with vertex at the seventh cervical vertebra; A2: angle related to the forward head posture with vertex in the external acoustic meatus; FE: angle related to the flexion/extension head position; DC: cervical distance, measures the curvature of the cervical spine; CVA: craniovertebral angle regarding the flexion/extension head position; CPL angle related to the position of forward head posture; CVT/EVT: cervical curvature ratio; level of significance: * $p<0.05$, ** $p<0.01$, Pearson's Correlation Coefficient (r).

Table 3 – Correlation between craniocervical variables evaluated by cephalometry and biophotogrammetry

Correlated variables	r	p
CVA x FE	-0.41	0.00*
CPL x A1	0.68	0.00*
CPL x A2	-0.11	0.14
CVT/EVT x DC	0.07	0.52

Cephalometric variables: CVA craniovertebral angle related to the flexion/extension head position; CVT/EVT cervical curvature ratio; CPL: angle related to the forward head posture. Biophotogrammetric variables: FE: angle related to the flexion/extension head position, A1: angle related to the forward head posture with vertex at the seventh cervical vertebra, A2: angle related to the forward head posture with vertex in the external acoustic meatus, DC: cervical distance, measures the cervical spine curvature; level of significance: * $p<0.05$, ** $p<0.01$, Pearson's Correlation Coefficient. (r).

angles, in both biophotogrammetric and cephalometric analyses obtained in the present study.

Recent studies have used cephalometry as a tool for analyzing the alignment of the head and cervical spine in individuals with and without temporomandibular disorder, considering the hypothesis of a possible association between

craniomandibular pain with the presence of postural changes in the craniocervical segment^{3,14,21}. During radiographic and biophotogrammetric analysis, all volunteers were instructed to maintain their habitual posture. Thus, it was important to adopt natural head position in this study for faithfully representing the position of the craniocervical structures.

There are different biophotogrammetric measures capable of measuring the forward head as well as the cervical spine curvature and the head flexion/extension. In a similar study, Silva et al.²² (2010) considered the use of the C7-tragus horizontal angle to characterize the forward head and the tragus-horizontal-eye angle to characterize the extension of the head.

Regarding the angular measurements used to assess the forward head posture through the biophotogrammetry (A1 and A2), a moderate and negative correlation between A1 and the angle of cranial flexion-extension (FE) was found. Thus, the forward head position required a head extension, possibly in order to maintain the horizontality of the optical plane²³.

A moderate and a negative correlation between A1 and the cervical distance was found, that is, the more forward head posture (lowest angle), the greater the cervical distance. Neiva et al.²⁴ (2009) reported that the forward head is characterized by the lower cervical flexion associated with the upper cervical extension, what in part, is in agreement with the photogrammetric findings of this study. The angles A1 and A2 showed to be consistent, but with a weak correlation.

In the analysis of cephalometric measurements, there were positive and moderate correlations between CVA and CPL. This finding strengthens the association between the forward head and the head extension. No significant correlation regarding the variable that measured the cervical curvature was observed (CVT/EVT).

Comparing the two different methods of assessment, the negative and moderate correlation between FE (biophotogrammetry) and CVA (cephalometry) reinforces the ability of the FE angle to evaluate head flexion/extension position. Furthermore, it was observed a positive and moderate correlation between A1 (biophotogrammetry) and CPL (cephalometry), confirming the ability of the A1 angle to evaluate the presence of a forward head. A positive and significant correlation between these variables was also demonstrated by Visscher et al.⁸ (2002), who also advocated the adoption of the natural head position during radiographic and photographic recordings. Similar craniocervical angular measurements were used by Van Niekerk et al.²⁵ (2008) in the correlation between the photography and radiography, but in the sitting position. The authors considered the photogrammetric measurements valid and reliable for postural assessment.

Gadotti et al.⁵ (2010) considered another angle formed between chin, external auditory meatus and sternal notch (in this paper named A2) for testing the sensitivity of photogrammetry in evaluating the head posture in the sagittal plane. In the present study, this same photogrammetric measure compared with equivalent purposes used in cephalometry

did not present significant correlation.

Rocabado¹³ (1983) reported that the head position on the neck related to the cervical spine curvature can be assessed by a distance (in cm) of a horizontal line, which has as reference the tangent to the apex of the thoracic spine, and the deepest point of the cervical spine. However, in this study, the DC (biophotogrammetry) showed no correlation with the cephalometric variable CVT/EVT expressing the cervical lordosis. Thus, it is assumed that this photogrammetric measure is best used for assessment of the forward head posture and not for the cervical curvature.

It is possible to study the craniocervical posture with reliable methods and without the exposure to radiation²⁶. Based on the association found between the two methods regarding the analysis of the measures that characterized the forward head and the head flexion/extension, it can be suggested the use of the biophotogrammetric method to assess the craniocervical posture.

Based on the correlations obtained between the postural assessment methods, it can be concluded that computerized biophotogrammetry, apart from being reliable, seemed to be adequate to evaluate the head position. However, for analysis of the cervical curvature, it is suggested the radiographic method as a more objective view of the bone structures which are not influenced by the soft tissues.

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