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Photometric analysis of the relationship between craniovertebral angle and facial profile in children aged 10–12 years

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ABSTRACT

Background: Head posture deviation is seen in 52.5 % of children aged 6–15 years. Studies have shown that poor posture habits can impair muscle function during craniofacial growth and development. A muscle imbalance causes abnormal positioning of dental and skeletal structures, a condition that exerts negative impacts, such as changes in facial morphology.

Objective: To determine through photometric analysis the relationship between craniovertebral angle as a function of head posture and glabella-subnasale-pogonion (G-Sn-Pg) angle as a function of facial profile in 10–12-year-old children, and the results will help to avoid facial development issues.

Methods: Thirty-three subjects met the inclusion criteria. Their craniovertebral angles and facial profiles were measured using lateral photometry and ImageJ. The craniovertebral angle was determined by connecting the tragus and C7 with a horizontal line, whereas the facial profile angle was determined by connecting the glabella, subnasale, and pogonion. The relationship between the craniovertebral and G-Sn-Pg angle values was analyzed using the Pearson correlation test.

Results: A significant relationship was observed between the craniovertebral angle and the G-Sn- Pg angle ($p < 0.05$), although such a relationship was weak ($r = 0.373$).

Conclusion: A more forward head posture is associated with a more convex facial profile, and this relationship is useful for the early prevention and treatment.

1. Introduction

During development, the craniofacial components, which perform stomatognathic functions, are interrelated and mutually support one another. When their function, growth, and development occur normally and in balance, a normal, harmonious, and balanced face shape and profile is achieved (Pachì et al., 2009).

Head posture, also known as craniocervical posture, is the position or orientation of the head as influenced by physiological factors, neuromuscular balance, and environmental conditions (Zokaitė et al., 2022). Head posture is mainly influenced by the force of gravity, but physiological needs (e.g., respiratory function), vision, balance, and hearing can also cause changes in head posture (Garg et al., 2019). Poor head posture can cause myofunctional disarranges in the craniofacial region. Head posture disorders occurring during development can result in modifications in growth and development. The development of the dentofacial complex is influenced by muscle balance in the craniofacial region. Muscle imbalance consequential to myofunctional disorders is often considered to cause abnormalities in the teeth and jawbone positions, notably in cases involving oral breathing, lip sucking, and tongue thrusting (Peng et al., 2022).

Head posture and facial profile analyses may be performed using the photometric method, which involves the measurement of the craniovertebral and glabella-subnasale-pogonion (G-Sn- Pg) angles. The photometric method has become widely used in clinics and research owing to its simplicity and non-invasiveness thanks to technological advances. This method includes the angular analysis of anatomical points marked on the skin and is interpreted in a digital photometric record (Weber et al., 2012).

By knowing the relationship between head posture and facial profile,

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dentists not only can understand the relationships between dental, skeletal, and soft tissues but can also analyze how head posture affects growth and development. Therefore, this study aimed to photometrically determine the relationship between craniovertebral angle as a function of head posture and G-Sn- Pg angle as a function of facial profile in 10–12-year old Deutero Malay children. The results may serve as bases in performing orthodontic treatments in children.

2. Materials and methods

2.1. Subject selection

The inclusion criteria were as follows: pediatric patients aged 10–12 years, belonging to the Deutero Malay race and having descended from two generations, having not received orthodontic treatment, are cooperative in doing lateral photometry, and having sharp and detailed digital lateral photometry results. Children with posture disorders, special needs, craniofacial abnormalities, and mouth breathing habit were excluded. The subjects were initially screened through a visual assessment; while standing, the subjects were assessed for posture changes, lack of lip seal, presence of dark under-eye circles, and having a long face; information were also obtained from their parents.

2.2. Photometric procedure

After a consent was obtained from the subjects' parents, a photometric procedure was performed, which was initiated by placing an anatomical marker using a sticker at the midpoint of the tragus and by attaching a styrofoam ball onto the C7 position for better visibility in the photograph. Next, the C7 position was determined by instructing the subjects to shift their cervical spine to a flexed position; then, the observer's index and middle fingers palpated the spinous processes of the two most protruded cervical vertebrae.

The subjects were subsequently assisted to perform extension movements. The spinous process of the lower cervical vertebra was marked C7 when it remained stationary while the palpated spinous process of the upper cervical vertebra moved anteriorly. The spinous process of the upper cervical vertebra was marked C7 when both the palpable spinous processes remained stationary.

The patients were asked to stand before a mirror, with their facial features, ears, and neck easily seen. Long hairs were drawn behind the ears, and accessories (e.g., eyeglasses and jewelry) were removed. The upper and lower teeth were in contact, whereas the lips were in light contact in the resting position.

To achieve a natural head posture (NHP), the subjects were asked to stand in a predetermined spot, which was 76 cm away from the wall, with their feet slightly apart and their arms relaxed. A mirror was fixed on the wall and was 71 cm away from the subject. Then, they were instructed to move their heads repeatedly with flexion and extension movements, starting from the maximum range and then reducing the range of movement gradually until their heads stopped moving and they could look straight into their eyes in the mirror. The true vertical line was represented by a weighted plumb line placed at the side of the subjects.

A right lateral view of the subjects was photographed as follows: the camera was mounted on a tripod in the portrait position, and it was set at the height of the subject's head and placed 130 cm from the side of the subject's feet. Lighting was provided by two LED lamps mounted on the wall facing the subject; the lamps were placed to the left and right of the subject; one LED lamp was illuminating the background. Three shots were taken, and the sharpest photograph was selected. In between shoots, the subjects were allowed to relax momentarily.

The obtained digital lateral photometric images were transferred and stored in a laptop. Then, the craniovertebral and G-Sn-Pg angles were analyzed using ImageJ (Fig. 1). Intra-observer and inter-observer reliability tests were carried out by assessing 10 samples.

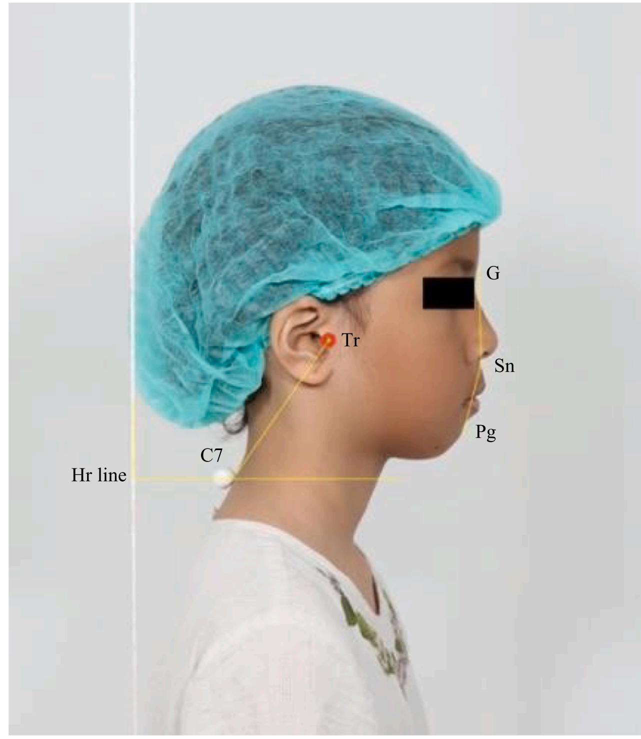

Fig. 1. Analysis the result of the photo using software. Tr: Tragus, C7: Spinous process, Hr line: Horizontal line, G: Glabella, Sn: Subnasale, Pg: Pogonion.

2.3. Statistical analysis

Intra- and inter-observer reliability were evaluated using the interclass correlation coefficient (ICC) test. Shapiro-Wilk test was used for testing the normality of the data. The relationship between head posture and facial profile was analyzed using the Pearson correlation test with significance level $p \leq 0.05$.

3. Results

Thirty-three children met the inclusion criteria, of whom 9 were male (27.3 %) and 24 were female (72.7 %). The craniovertebral and G-Sn-Pg angles are presented in the numerical data. The intra-observer ICC values for the craniovertebral and G-Sn-Pg angles were 0.966 and 0.979, respectively, and the corresponding inter-observer ICC values were 0.955 and 0.985. These findings indicate an excellent agreement between the intra-observer and inter-observer reliability values for the craniovertebral and G-Sn-Pg angles.

Table 1 shows the homogeneity test results for the craniovertebral and the G-Sn-Pg angles according to gender, and the results (0.841 and 0.864, respectively; $p > 0.05$) indicated that the data were homogeneous.

The normality test results for the craniovertebral and G-Sn-Pg angle measurements were 0.970 and 0.579 ($p > 0.05$), respectively, indicating

Table 1
Homogeneity test results for the craniovertebral and G-Sn-Pg angles according to gender.

	Average ± SD(degree)	p value	Data Variance
Craniovertebral angle			
Male	52.22 ± 6.23	0.841	homogeneous
Female	51.93 ± 4.72		
G-Sn-Pg angle			
Male	168.13 ± 4.51	0.864	homogeneous
Female	168.81 ± 4.65		

the normal distribution of the data.

Table 2 shows the results of the photometric analysis of the relationship between the craniovertebral and G-Sn-Pg angles of the investigated subjects. The average craniovertebral angle was 51.590 ± 4.595, and the average G-Sn-Pg angle was 168.716 ± 4.362. In the Pearson's r test, a p value of 0.033 was obtained, indicating a significant relationship ($p < 0.05$) between the two parameters, although such a positive (unidirectional) relationship was weak, as indicated by $r = 0.373$.

4. Discussion

A balanced soft tissue tension (involving facial skin and muscles) in relation to the craniocervical bones, myofascial structures, and dental occlusion promotes proper head posture. A study has shown a high prevalence of head posture deviation (Batistão et al., 2016; Verma et al., 2018). Muscle imbalance consequential to myofunctional disorders is often considered to cause abnormalities in teeth and jawbone positions (Peng et al., 2022). This can negatively affect the skeletal system, specifically the alteration of facial morphology (Garg et al., 2019).

The digital lateral photometry method was used in this study because it is simple, economical, time-saving, non-invasive, and easy to apply clinically and thus is widely used in research. The photometric method demonstrates a good validity compared with the radiographic method (Van Niekerk et al., 2008). Nevertheless, craniovertebral angle measurements obtained using these methods do not significantly differ (Visscher et al., 2002).

The age range for the research subjects was set to 10–12 years. At this age range, craniofacial growth and development have reached approximately 80 %, and the head posture and facial profile are already stable (Bishara et al., 1985; Sidlauskas et al., 2005).

Children with special needs were excluded from this study; taking lateral view photos, which would require the subjects to follow a set of instructions, would be difficult when dealing with children with special needs. Children with posture disorders and those who breathe through the mouth were also excluded from this study. In the latter condition, changes in head posture and facial growth patterns occur as adaptations to the said habit (Calvin et al., 2017). Postural abnormalities can also result in craniofacial changes. Children with kyphosis tend to have a smaller SNB angle, and scoliosis posture is significantly correlated with the occurrence of crossbite and mandibular midline deviation (Šidlauskienė et al., 2015; Sambataro et al., 2019).

Meanwhile, site preparation, photographer's position, camera settings, subject's position, and lighting are important aspects in standardizing data collection and in obtaining images showing clear anatomical details (Ahmad, 2020). In this study, the subjects were photographed in the same location; the photographer was positioned behind the camera, which was placed 130 cm from the subject.

The recommended camera settings for taking lateral view clinical portraits are ISO 100, f11 (aperture), and 1/125 or 1/250 (shutter speed) (Ahmad, 2020). However, these settings can be adjusted according to the camera being used and the lighting condition. In this study, the camera settings were as follows: ISO 200, f4, and 1/30.

Digital lateral photometric images were taken with the subjects' head in the NHP using the mirror guide method. In most clinical photography and direct clinical examinations, subjects' heads must be in the NHP (Meneghini and Biondi, 2012). NHP refers to the head's balanced position in a relaxed state, with the eyes looking straight forward and focusing on a point at eye level; the visual axis is parallel to the horizontal plane. The research conducted by Jakobsone et al. (2020) demonstrated that the mirror-guided position is steady and reproducible (Jakobsone et al., 2020).

In this study, the head posture was assessed through craniovertebral angle measurement. This parameter is a strong indicator of head posture and is regarded as the clinical standard for assessing head posture (Gadotti, 2010; Lee et al., 2015). Children are considered as having a forward head posture (FHP) when their craniovertebral angle is smaller than 50°; the smaller the angle, the more forward the head is (Ibrahim and Radwan, 2018). The current craniovertebral angle measurements had a mean value of 51.590 ± 4.595. In previous studies, the mean value of the craniovertebral angle for children aged 7 until < 8 years was 50.00 ± 4.7 for males and 45.6 ± 4.4 for females; in children aged 8–9 years, the mean craniovertebral angle was 48.2 ± 4.1 for males and 47.5 ± 4.8 for females. However, no significant difference was observed between the males and females in terms of their craniovertebral angle values (Shaheen and Basuodan, 2012).

Table 2
Photometric analysis of the relationship between craniovertebral angle and G-Sn-Pg angle of the investigated 10–12 year-old Deutero Malay children.

Variable	n	Average ± SD (degree)	r	P value
Head posture (craniovertebral angle)	33	51.590 ± 4.595	0.373	0.033*
Facial profile (G-Sn-Pg angle)	33	168.716 ± 4.362		

* Pearson Test, $p < 0.05$.

The G-Sn-Pg angle (the facial convexity angle) can indicate maxillary and mandibular malrelation in the sagittal plane. In this study, the average G-Sn-Pg angle was 168.716 ± 4.362, which is close to the average values obtained in a study involving normal children aged 12 years; the reported values were 168.10 ± 5.10 for males and 169.85 ± 4.83 for females (Leung et al., 2014).

In this study, based on the correlation test between craniovertebral angle (which is a function of head posture) and G-Sn-Pg angle (which is a function of facial profile), a significance (p) value of 0.038 was obtained with a correlation strength (r) of 0.363. This shows a significant relationship but a weak positive correlation between head posture and facial profile. The G-Sn-Pg angle decreases with decreasing craniovertebral angle, suggesting that changes to a more forward- positioned head posture are associated with a more convex face profile. According to the theory of the soft tissue stretching mechanism, stretching of the soft tissues covering the facial bones produces a dorsal force on the dento-facial structure, hindering facial growth in the frontal direction (Solow and Sonnesen, 1998).

5. Conclusion

There was a significant relationship between the head posture's craniovertebral angle and the facial profile's G-Sn-Pg angle with weak relationship strength, in children age 10–12 years. Based on this, it can be concluded that head posture is an aspect that needs to be considered in carrying out orthodontic and also orthopedic treatment so that early intervention and treatment can be carried out immediately. Future research should analyze a population with a wider age range, as the craniofacial growth in individuals aged 10–12 years is only 80 %.

CRediT authorship contribution statement

Maya Rosita: Investigation, Software, Writing - original draft, Writing - review & editing. **Sarworini B. Budiardjo:** Supervision, Conceptualization, Formal analysis, Funding acquisition. **Mochamad Fahlevi Rizal:** Methodology, Project administration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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