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Original Article

## Craniocervical Posture in Children with Class I, II and III Skeletal Relationships

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### Abstract

**Objective:** To describe the characteristics of craniocervical posture of children aged between 6 and 11 years and its relationship to their sagittal skeletal classification. **Material and Methods:** This descriptive cross-sectional study involved 107 children (55 girls - 52 boys), aged between 6 and 11 years. The sample included no previous orthodontically/orthopedic treated and systemically healthy children. After proper calibration, lateral skull radiographs, taken for diagnosis purpose for maxillary orthopedic treatment, were obtained by the same operator in natural head position. A radiographic analysis was made using a NEMOTEC software: 13 variables were registered: age, gender, ANB angle (to classify sagittal skeletal relationships) and 10 variables related to craniocervical posture: cervical lordosis, hyoid triangle, craniocervical angle, intervertebral spaces: C0-C1, C1-C2 and distances NSL-Ver, NL-Ver, ML-Ver, OPT-Hor, CVT-Hor. To evaluate the reliability of measures, 15 randomly selected radiographs were re-measured by the same investigator two weeks after the initial analysis. **Results:** Intra-class correlation coefficients were in a range of 0.945-0.996. Lordosis, CCA, C1-C2, OPT-Hor y CVT-Hor, values were higher in male than in female children ( $p < 0.05$ ). No statistically significant differences were found among groups of sagittal skeletal relationships, but class III children had a tendency to higher craniocervical flexion; 66.3% of the studied group presented rectified lordotic curvature and class II subjects presented increased values of NSL-Ver, NL-Ver and ML-Ver. Class I children had the lowest values for OPT-Hor and CVT-Hor. **Conclusion:** All craniocervical postural variables were higher in boys than in girls. No differences were found in this study between cervical postural variables with different malocclusion.

**Keywords:** Cervical Vertebrae; Craniocervical; Posture; Malocclusion.

## Introduction

The biomechanic connection between head position and cervical position (craniocervical posture), temporomandibular joints and sagittal skeletal relationships is a subject of growing academic interest. These complex systems form a unit, due to the close anatomic relationship between the components and its static and dynamic interaction [1]. It has been reported that, if the proprioceptive information to the stomatognathic system is inadequate, then, body and head control position may be affected [2].

Many studies have been published during the last century aiming at getting insight into cranial, cervical and stomatognathic system relationships. In 1926 an author showed this inter-relationship in children with obstruction of the upper airway. These children had head extension, caused by a difficulty to breath; this eventually led to the development of class II malocclusion [3].

A number of studies demonstrated that dental occlusion, sagittal relationships and the craniofacial pattern, have influence on head position [3–10]. Although in the Consensus Conference on Posture and Occlusion: Hypothesis of Correlation, held in 2008, it was concluded that only mild evidence supported the hypothesis of correlation between posture, corporal dynamics and occlusion [11], a systematic review published in 2014 found a significant association between head position, cervical posture and craniofacial morphology. It suggested that such association should be carefully interpreted because the correlation coefficients were low or moderate [12]. Recently, and using tomographic cone beam it was concluded that relationships between the cranial base structures, the structures that determine the sagittal position of the maxilla, mandible and chin, and the cervical vertebrae complex and hyoid bone exist [13]. According to the above, there is no consensus on whether or not there is a strong relationship between craniocervical posture and malocclusions.

Few studies have been performed in children to study the relationship between craniocervical posture and sagittal skeletal relationships [4,5,9,10]. For that reason, the objective of this study was to describe lateral cephalic radiographic characteristics related to craniocervical posture in children, and its relationship to sagittal skeletal classification. The importance of this study lies in improving the knowledge and understanding of inter-relationships between craniocervical posture, and malocclusion in growing and developing individuals in order to establish more complete diagnoses. Also, this kind of research could be a start point to initiate intervention studies to appreciate the changes in cranio-cervico-mandibular relationships when different therapeutic approaches are applied to patients in that age range. Therefore, clinicians could offer better therapeutic approaches to patients.

## Material and Methods

The study design was descriptive cross-sectional. Cephalometric radiographs were taken, for diagnosis purpose, to some children selected from a program of the Mayor's office, referred for maxillary orthopedic treatment. A non- probabilistic sample of 107 children who met the inclusion criteria were selected. A written interview was answered by the adult in charge and the children

passed through a clinical exam. They were selected by the following inclusion criteria: children aged between 6 and 11 years, no previous orthodontic/orthopedic treatment, and good general health condition. Exclusion criteria: Any craniofacial syndrome and/or systemic condition affecting skeletal muscle function, diagnosis of mouth breathing, history of craniofacial or cervical trauma, evidence of asymmetries, cervical dysfunction, temporo-mandibular joint disorders, visual alterations affecting head posture (e.g. palpebral ptosis).

The X-ray equipment used was Sirona, Orthopos Xg5, operating at 73 Kv, 15 mA, 9.4 seconds. After calibration, all radiographs were obtained by the same operator, following the mirror protocol [4,14,15]. This was performed in natural head position, which involves the patient standing, in orthoposition, feet separated at comfortable distance, slightly divergent, fixed guides located on the floor, the eyes looking at mirror reflex (45x98cm) placed at 1.10 meter. The child was instructed to do 4 deep air aspirations. Finally, the olives were gently placed without entering the ear channel, and the nasion was located without pressure in order to maintain the position of the patient.

The real vertical dimension was determined by a plumb line, and parallel to it, a caliper 0,36 round wire was fixed to the millimeter ruler of nasion of the equipment. The wire was visible in the radiographic image representing the real vertical dimension. The patient was protected by a lead coat. This coat was located at the right side of the patient (beam direction), externally supported by a metallic arm graduated according to the child size, in order to avoid changes in the natural head position.

The radiographic analysis was made using a Nemotec software, in a Hewlett-Packard Pavilion MS200 computer. The calibration for each radiograph was 1:1. Previous to data acquisition the system was standardized to locate and take the postural measurements. One investigator placed 20 points on each radiograph; then 10 planes were drawn and 7 angles and 4 distances were measured using the software. In order to evaluate the reliability of measures, 15 randomly selected radiographs were re-measured by the same investigator, two weeks after the initial analysis. Intraoperator agreement for all postural variables were evaluated by intra-class correlation coefficient.

Thirteen variables were registered: gender, age, maxillomandibular ratio (Steiner's ANB angle [16]). This angle is commonly used in different studies to classify sagittal skeletal relationships [5,9,10,17-21]) and 10 variables related to craniocervical posture (6 angles and 4 distances) described by some authors [22-24] (Figure 1).

#### Reference Points:

S: Sella, center of the sella turcica [16].

N: Nasion, most anterior point of frontonasal suture [16].

A: Point A, most posterior point of the anterior curvature of the alveolar maxillary process [16].

B: Point B, most posterior point of the anterior curvature of the alveolar mandibular process [16].

ANS: Anterior nasal spine, most anterior point of nasal spine [5].

PNS: Posterior nasal spine, most posterior point of the maxillary at palatal level [5].

Gn: Gnathion, the most anterior-inferior point of the chin [4].

RGn: Retrognathion, the most posterior-inferior point of the mandibular symphysis [23].

Go: Gonion, mid-point between the most posterior and inferior portion of the mandible [4].

Oc: Occipital point, the most inferior point of the occipital bone [23].

H: Hyoidale, the most anterior and superior point of hyoid bone [23].

C1s: Point C1s, most superior and posterior point of the posterior arch of the atlas bone [9,23].

C1i: Point C1i, most inferior and posterior point of the posterior arch of the atlas bone [9].

C2: Point C2, most superior and posterior point of C2 spinous apophysis [9].

Cv2tg: Point most superior and posterior of the odontoid body [5,22,24].

Cv2ip: Point most posterior and inferior of the odontoid body [5,22].

Cv3ip: Point anterior and inferior of the third vertical vertebra body [23].

Cv4ip: Point most posterior and inferior of C4 [5,22].

Cv7ip: Point most posterior and inferior of C7 [24].

Ops: Point most superior of the odontoid [23].

Opi: Point most anterior and inferior of the odontoid [23].

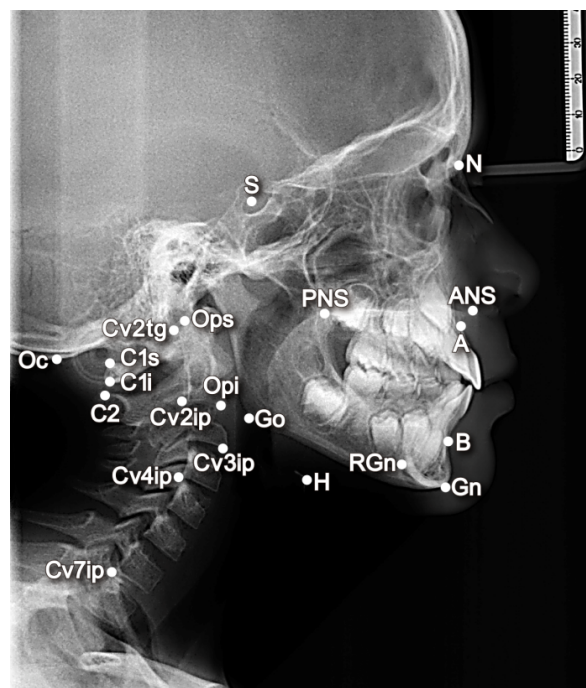


Figure 1. Reference Points used for Cephalometric Tracing.

Reference Planes:

NSL: S-N

NL: ANS-PNS

ML: Go-Gn

McGregor: PNS-Oc

OPT: Cv2tg-Cv2ip

CVT: Cv2tg-Cv4ip

OP: Odontoid Plane Ops-Opi

Ver: Real Vertical

Hor: Real Horizontal, plane perpendicular to Ver

#### Reference Angles:

ANB: Internal angle [16].

NSL-Ver: inferior and external angle [22].

NL-Ver: Inferior and external angle [22].

ML-Ver: inferior and external angle [22].

Craniocervical angle (CCA): OP-McGregor: inferior and external angle ( $96^{\circ}$ - $106^{\circ}$ ) [23].

OPT-Hor: superior and internal angle [22].

CVT-Hor: superior and internal angle [22].

#### Reference Distances:

SS: Superior space: distance between the tangent of the occipital base delimited for Mc Gregor plane and C1s point (4-9 mm) [9,23].

IS: Inferior space: distance C1i-C2 (4-9 mm) [9].

Hyoid triangle: position of hyoid-bone in relation to the triangle formed by the union of the H-Rgn-Cv3ip planes. It is measured in mm from the apex (H) to the plane Cv3ip-Rgn: Normal (3-7 mm), hyoid ptosis ( $> 7$ ), level (0-2.9), negative ( $< 0$ ) [23].

Lordotic curvature (lordosis): a tangent is drawn from Cvt2tg to Cv7ip (Penning technique); [24] and from the midpoint of the deepest vertebra a perpendicular is drawn to this tangent and this perpendicular is measured. Normal depth:  $10 \pm 2$  mm; rectified:  $< 8$  mm; kyphotic:  $< 1$ ; hyperlordotic:  $> 12$  mm.

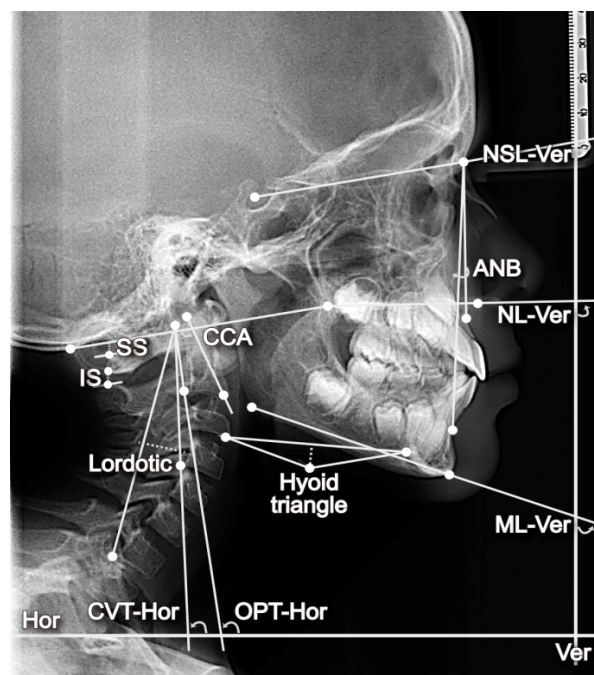


Figure 2. Reference Planes, Angles and Distances.



## Data Analysis

The data analysis was carried out with the statistical program IBM-SPSS (version 21; SPSS). Quantitative variables were expressed as average  $\pm$  standard deviation and 95% confidence intervals (CI 0,95). The Kolmogorov-Smirnov test was used to evaluate the normality of the sample distribution. Qualitative variables were expressed as absolute and relative frequency. Differences in craniocervical postural data among sagittal skeletal relationships were estimated by one – way Anova test. The Student t test was applied to compare gender differences regarding cervical posture. Bivariate correlations in relation to age, were also established. The level of significance for statistic tests was established as  $p = 0,05$ .

## Ethical Aspects

This study was performed after approval by the Ethics Committee on Research with human subjects of the Faculty of Dentistry where the study was performed (Act of approval number 4 from June 18, 2014). It was classified as of “minimum risk” to the patient, according to the Helsinki Declaration from the World Medical Association (2004) and the Country Norms indicated in the Resolution 008430 (1993) from the Ministry of Health. Each adult in charge of the children signed the informed consent authorizing the confidential use of the radiographs for this study.

## Results

Intraoperator agreement for all postural variables was evaluated by intra-class correlation coefficients that were in a range of 0.945-0.996.

The mean age of the sample was  $8.56 \pm 1,5$  years (girls  $8.5 \pm 1.4$ ; boys;  $8.6 \pm 1.56$ ). Age differences between gender groups were not statistically significant.

Figure 1 shows that more patients were found in class I malocclusion, being more prevalent in girls. On the other hand, class II prevailed more in boys. Class III was the least prevalent malocclusion, being equal between boys and girls.

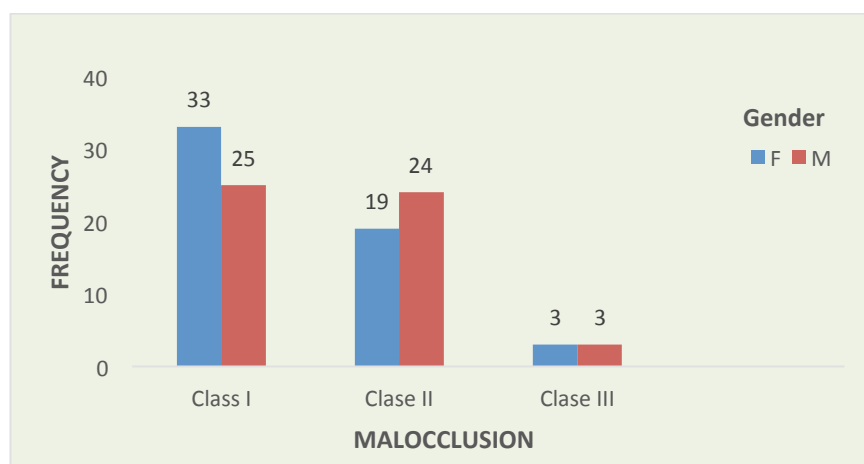


Figure 1. Distribution of the sample by gender and malocclusion.

An exploration was made to know if age was related to any of postural variables and no relationship was found. Therefore, the following table shows the results of postural variables in the entire sample. Table 1 shows mean, Standard Deviation (SD), minimum and maximum of postural variables.

**Table 1. Description of postural variables in children aged between 6 and 11 years.**

Variable	Mean	S.D	Min.	Max.
Lordosis (mm)	5.7	3.7	-4.0	15.6
Hyoid Triangle (mm)	4.8	3.8	-2.9	17.1
CCA (degree)	106.0	8.6	85.9	127.0
Sup. space: SS (mm)	6.3	2.4	0.9	12.6
Inf. space: IS (mm)	4.8	2.1	1.2	10.5
NSL-Ver (degree)	99.9	4.0	89.0	108.0
NL-Ver (degree)	91.7	4.4	80.0	100.5
ML-Ver (degree)	67.2	4.8	52.0	78.0
OPT-Hor (degree)	91.1	7.7	69.5	112.0
CVT-Hor (degree)	89.6	7.1	69.5	107.5

Significant differences were found for lordosis, CCA, inferior space, OPT-Hor and CVT-Hor when postural variables were compared by gender, with higher average values for boys (Table 2).

**Table 2. Postural variables according to the gender.**

Variable	Boys (n=52)		Girls (n=55)		<i>p value</i>
	Mean $\pm$ S.D.	CI 95%	Mean $\pm$ S.D.	CI 95%	
Lordosis (mm)	6.7 $\pm$ 3.6	5.7-7.7	4.8 $\pm$ 3.6	3.8-5.8	.009*
Hyoid Triangle (mm)	5.1 $\pm$ 3.5	4.1-6.0	4.6 $\pm$ 4.1	3.4-5.7	.507
CCA (degree)	108.2 $\pm$ 8.2	106.0-110.5	103.9 $\pm$ 8.5	101.6-106.2	.008*
Sup. space: SS (mm)	6.7 $\pm$ 2.6	6.0-7.5	5.9 $\pm$ 2.1	5.3-6.4	.055
Inf. space: IS (mm)	5.5 $\pm$ 1.9	5.0-6.0	4.2 $\pm$ 2.2	3.6-4.8	.002*
NSL-Ver (degree)	100.0 $\pm$ 3.9	98.9-101.1	99.7 $\pm$ 4.2	98.6-100.8	.683
NL-Ver (degree)	92.0 $\pm$ 4.1	90.9-93.1	91.5 $\pm$ 4.8	90.2-92.8	.534
ML-Ver (degree)	67.4 $\pm$ 4.9	66.0-68.8	67.1 $\pm$ 4.7	65.9-68.4	.822
OPT-Hor (degree)	93.9 $\pm$ 7.1	91.9-95.9	88.5 $\pm$ 7.4	86.5-90.5	.000*
CVT-Hor (degree)	93.0 $\pm$ 6.1	91.3-94.7	86.5 $\pm$ 6.6	84.7-88.3	.000*

\* $p < 0.05$ . Standard Deviation (SD).

Additionally, the bivariate correlation coefficients for all postural variables regarding age were calculated but they were no significant. The highest value was for superior space (SS) with a variation of 22%, explained by age, but was not significant as well.

All postural variables had normal distribution, except the inferior space; therefore parametric test were applicable in consequence. This distribution of postural variables for different sagittal skeletal classification is presented in Table 3.

**Table 3. Distribution of postural variables by sagittal skeletal classification.**

Variable	CLASS I (n=58)		CLASS II (n=43)		CLASS III (n=6)		<i>p value</i>
	Mean $\pm$ S.D.	CI 95%	Mean $\pm$ S.D.	CI 95%	Mean $\pm$ S.D.	CI 95%	
Lordosis (mm)	5.3 $\pm$ 3.7	4.4-6.3	6.3 $\pm$ 3.9	5.1-7.5	5.3 $\pm$ 3.1	2.1-8.5	.542
Hyoid Triangle (mm)	4.7 $\pm$ 4.2	3.6-5.8	5.2 $\pm$ 3.4	4.1-6.2	3.1 $\pm$ 3.0	-0.05-6.3	.842
CCA (degree)	105.3 $\pm$ 8.7	103.0-107.5	106.6 $\pm$ 8.6	104.0-109.2	108.9 $\pm$ 8.2	100.3-117.4	.556
Sup. space: SS (mm)	6.0 $\pm$ 2.3	5.4-6.6	6.4 $\pm$ 2.5	5.7-7.2	7.8 $\pm$ 1.9	5.8-9.7	.306
Inf. space: IS (mm)	4.5 $\pm$ 2.3	3.9-5.1	5.2 $\pm$ 1.9	4.6-5.8	5.6 $\pm$ 2.6	2.9-8.3	.185



NSL-Ver (degree)	99.8±4.1	98.8-100.9	100.3±4.0	99.1-101.5	97.1±2.9	94.0-100.2	.198
NL-Ver (degree)	91.5±4.6	90.3-92.7	92.5±4.2	91.2-93.8	88.4±2.6	85.7-91.1	.068
ML-Ver (degree)	67.4±4.8	66.1-68.7	67.3±4.9	65.8-68.8	65.3±3.8	61.4-69.3	.922
OPT-Hor (degree)	90.3±7.6	88.3-92.3	92.0±8.2	89.5-94.5	91.8±7.7	85.5-98.0	.459
CVT-Hor (degree)	88.8±7.1	86.9-90.6	90.6±7.3	88.4-92.9	91.1±5.9	84.9-97.3	.270

Standard Deviation (SD).

No statistically significant differences for postural variables among skeletal class I, II and III were found, but there were some tendencies that will be mentioned in the Discussion section.

## Discussion

This study evaluated the craniocervical posture in children aged 6 and 11 years. Most published studies evaluated the cervical column position in adults; therefore, the results of this study contribute to the scientific knowledge on this topic for growing subjects.

Postural variables were presented for the entire sample without age stratification, because it was found that none of postural variables were related to patients' age. This finding is in agreement both with some authors [6,25]. On the contrary, a study investigated the relationship between craniofacial morphology, head position and cervical curvature in 8, 11 and 15 year old subjects, found that cervical lordosis as measured by angles CVT/Ver and OPT/Ver, was reduced as age increased, but did not specify if differences were statistically significant [26].

Variables presenting significant sexual dimorphism were: lordosis, CCA, inferior intervertebral space, OPT-Hor and CVT-Hor. All of above average values were significantly higher in boys than in girls. This is coincident with some authors that have reported sexual dimorphism in craniocervical posture [25,27]: other researchers visually classified the cervical spine curvature in lateral cephalic radiographs, and mentioned that men generally exhibited a more straight cervical curve while in women the curvature were partially inverse [27]. Other study also found an influence of gender in the curvature of the cervical column, but did not explain which was the difference [25]; on the contrary, publications in adults and children found that cervical curvature was independent of sex [6,28]. Different results were likely due to difference in age of populations studied and/or different methods of evaluating cervical curvature.

Regarding skeletal relationships, in this study the association between postural variables and sagittal skeletal relations was not statistically significant. This is in accordance with a recent study performed in patients between 15 and 19 years old, where no significant differences between class I and class II malocclusions for the indicator angles of cranial posture except for ML/Ver [29].

A previous study of 23 children, skeletally classified according to the Antero-posterior dysplasia index (APDI), found a craniocervical posture more straight in class III patients compared to class I. For other variables no statistically significant differences were reported [4].

Another study of Chinese children found that skeletal class II subjects showed the largest craniovertical and craniocervical angles, while skeletal class III subjects showed the smallest ones, although not all the measurements evidenced significant differences [28]. On the other hand, a study

evaluated cervical posture in  $9,5 \pm 0,5$  years old children, classified as skeletal class I, II and III, and concluded that neck posture was strongly associated to sagittal and vertical facial structures [5].

Later, another study reported a mild significant association between patients with sagittal skeletal classification and altered craniocervical posture [9]. Another study reported that the position of the head and neck, is related to the craniofacial morphology and to type II, division 1 malocclusion [30].

A study of clinical evaluation of head posture with photographs in patients of 16 to 40 years old revealed a predominance of anteriorized head posture in class II individuals compared to class III individuals [31]. In the same way, another study with digital photographs of the entire body, looking for cervical lordosis, found that 25% of patients with Class II and Class III malocclusion presented values out of the normality range, and 92% of Class III patients showed forward head position [32].

Other authors suggest that the association between the change in posture and growth direction of the face most likely arises from the coordinated postural behavior of the mandible and tongue, which determines the growth direction of the mandible and, at the same time, influences the cranio-cervical angulation [33].

As previously mentioned, an author [4] used the APDI for sagittal skeletal classification, while the ANB angle was used in this and other studies [5,9,28,34]. The differences of the findings observed in mentioned studies are probably due to different methods of observation used and/or the different ages of the patients.

The tendencies observed in some postural variables related to the type of sagittal skeletal classification are discussed below.

**OPT-Hor, CVT-Hor:** refer to cervical inclination. OPT is defined as the superior part of the column and CVT is the middle part, closely related to the facial development [5].

Variables OPT, CVT and the angle they form with the horizontal planes were evaluated and no statistically significant differences were found in relation with the skeletal classification. This is in accordance with the studies performed by other authors that didn't find significant differences among the three skeletal classes in cervical posture [5]. On the contrary, another study found the highest values for these variables in class III patients, suggesting a tendency to a more right position of the column, or less lordotic, but taking into account that there are many other factors, this may have influence on that position [4].

**CCA:** A recent study [10], as in this study, evaluated a group of children aged between 7 and 12 years with class I, II and III sagittal skeletal relationships; they found that in 100% of the group CCA was reduced compared to the normal range taken from a previous study ( $96^{\circ}$ - $106^{\circ}$ ) [23]. This indicates an extension of the cranium with respect to the cervical column. Class III children presented the highest value for this angle [10]. Contrary to that report, this study found that class I and II children presented a CCA within the normal range, but coinciding with the first author of this

paragraph[10], the class III patients had the highest CCA values, showing a tendency to skull flexion compared to the cervical column.

In 2011 a study [9] found that when CCA increased, the ANB was reduced. In this study class III children showed the highest CCA values, in accordance with other author [4] suggesting that class I and II patients have more head flexion.

**Superior (SS) and Inferior (IS) intervertebral spaces:** The distance between intervertebral spaces may change within the functional range between 4 and 9 mm [23]. In this study, the superior and inferior intervertebral spaces were within this range, similar to the values reported by a previous study mentioned before for the superior space [10]. The class I children with low CCA from this study presented smaller values for this space. Another study [4] found that a lower CCA corresponded to a minor distance for the superior intervertebral space, suggesting an extension or backwards head position.

**Lordosis:** 66.3% of the total sample presented lordotic rectified curvature: class I and III subjects presented low values, and some class I children presented kyphosis of the cervical column. These results were different to those found by other authors [5,14]. One of them [5] stated that the cervical column was significantly more straight in class III subjects than in class I and II. However, cervical lordosis in that study was estimated by the CVT/EVT angle. Another author that used CVT/EVT found a negative correlation between cervical lordosis and mandibular length [35]. Another study [14] reported a reduced lordosis in class II patients, using a method to measure the lordotic curvature similar to the method used in this study, but their classification of sagittal malocclusion was based on molar relationship. The lack of agreement among the different studies mentioned is likely to be related to different methods to measure lordosis and/or to express the sagittal relationship.

As this study was only aimed to descriptive, it was not possible to consider a cause-effect relationship between sagittal skeletal relationships and postural variables. It is strongly recommended to design analytical studies with calculated sample size, longitudinal and intervention studies to evaluate craniocervical outcomes from different therapeutic approaches, in order to treat altered sagittal skeletal patterns.

## Conclusion

All craniocervical postural variables were higher in boys than in girls. In this study no differences were found between cervical postural variables in children with different malocclusions.

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