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Relationship between craniocervical posture, mandible and hyoid bone and influence on alimentary functions

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Abstract

Aim: To evaluate the anatomical relationship between craniocervical posture and mandibular and hyoid bone position and the influence on the masticatory and swallowing functions. **Methods:** Thirty-six women aged 19 to 35 years without temporomandibular disorder diagnosis were evaluated. Variables related to the craniocervical posture and mandibular and hyoid bone position were obtained by cephalometric measurements. Masticatory and swallowing function evaluations were performed according to a protocol of orofacial myofunctional evaluation with scores. **Results:** Significant correlations were observed between craniovertebral angle and the linear distance from the hyoid bone to the mentum (p=0.02) and to the mandible (p=0.03). The angle that measured the forward head position also demonstrated a significant correlation with the linear distance between hyoid bone and jaw (p=0.00). The cervical curvature degree showed a significant correlation with the linear distance from hyoid bone to the third cervical vertebra (p=0.01). Modifications of the cranium base inclination in relation to the cervical column at the two levels (NSL/CVT and NSL/OPT) were the only variables, which showed a significant correlation with the mandible position. Important craniocervical postural changes were observed in the subjects, although there was no association between them and a higher frequency of atypical behaviors evaluated during masticatory and swallowing functions. **Conclusions:** Cephalometric findings confirm the anatomical relationship between craniocervical posture, mandible and hyoid bone. However, association between craniocervical posture alterations and masticatory and swallowing function impairments was not detected. Such findings suggest that, in the presence of a musculoskeletal imbalance, the body readapts itself ensuring that alimentary functions will not be affected.

Keywords: posture, mastication, deglutition, cephalometry.

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Introduction

Considering the human biomechanical principles, it is known that there is interdependence between the structural condition and the action of the movement. In other words, the muscle action, on which the performance of several functions of the organism depends, is determined by the muscle-skeletal balance relationship of the body segments observed in the posture called ideal[1].

Therefore, the influence of the craniocervical posture on the functionality of the stomatognathic system may be based on the concept of the craniocervicomandibular unit, which defines the muscle-skeletal relationship covered by head, neck and mandible[2]. The hyoid bone, despite not being articulated to the system, it maintains muscle connections with the cranium basis and with the mandibular symphysis, and fascial connections with the cervical column[3]. A synergism between the tonic-postural cervical, masticatory, supra and infrahyoid muscles is established up to the point that a craniocervical change may alter it and consequently, the mandibular and hyoid bone position as well[4].

The conditions of mandibular and hyoid bone at rest, in turn, are determinants in the performance of the stomatognathic alimentary functions. The efficient chewing is exerted through a coordinated interaction between the mandible, tongue and hyoid movements with the occlusal plane alignment and the masticatory muscle performance[5].

During swallowing, the stabilization of the mandible to the cranium is the first physiological event that permits the action of the tongue and hyoid in the food bolus propulsion. The antero-superior displacement of the hyoid bone is also essential in the airway protection against the aspirations and in the food passage through the upper esophageal sphincter[6-7].

Based on the above-mentioned, it can be inferred that the aligned craniocervical posture is necessary for a good performance during alimentary functions. However, no similar study was found aiming to investigate qualitatively the craniocervical posture simultaneous to the clinical evaluation of myofunctional orofacial ability during masticatory and swallowing functions.

On the other hand, it was found an increasing number of researchers concerned about elucidating the still unclear relationship between stomatognathic and postural systems[8-9]. For this purpose, several mechanical or electronic devices are used such as surface electromyography, kinesiography, postural platforms, among other tools. However, their use in the clinical practice, beyond being far from most professional's reality, has been criticized because of the absence of normative values controlled for age, sex, weight, and facial morphology.

Thus, it still remains essential to deepen into this issue, encouraging the application of a functional instrumental assessment in order to answer more specifically some daily clinical questions of the professionals involved in the diagnostic and treatment of patients who suffer from disturbances in any of these systems. Therefore, the aim of the present study was to investigating the anatomical relationship between the craniocervical posture, mandible and hyoid bone position, by means of the cephalometric analysis, as well as the influence on the masticatory and swallowing functions. Due to the scope of the subject, this study emphasized only these functions, excluding breathing and phonoarticulation, which are also influenced by the craniocervical posture and could be investigated in further studies.

Material and methods

This study was a transversal and observational investigation with a quantitative approach. Females aged 19 to 35 years, interested in a free functional evaluation of the orofacial and cervical regions, were invited to take part in this study. The research project was approved by the Ethics Committee of the Federal University of Santa Maria (UFSM), under protocol number 0048.0.243.000-08.

The exclusion criteria of the study were: temporomandibular disorder (TMD) diagnosis, facial trauma, craniomandibular and/or cervical surgical procedures, musculoskeletal deformities, class II and II subdivision malocclusion, tooth loss, anterior and posterior open bite, cross bite, level bite and overbite, as well as current use of orthodontics appliance.

For subject selection, the TMD diagnosis was evaluated by the same examiner, according to Research Diagnostic Criteria for Temporomandibular Disorder (RDC/TMD)[10]. Malocclusion was evaluated by an orthodontist by observation of intraoral photographs .

From August 2010 and May 2011, 94 subjects contacted the researcher as answer to an invite published in press and electronic media. From these, 58 were excluded and oriented to look for specialized treatment. The subjects with TMD were invited to take part in the project of physical therapy at UFSM.

The body mass index (BMI) and age were analyzed to characterize and standardize the volunteers. Therefore, the study was carried out with 36 women who agreed in taking part in the study by signing an informed consent form.

For the cephalometric analysis, the volunteers underwent a right lateral cranium and cervical column radiograph in orthostatic position. In order to reproduce the natural head positioning, the volunteers were oriented to glance at their eyes in a mirror placed in one-meter distance[11].

The radiograph was carried out using the Orthophos Plus x-ray unit (Siemens, German) with 1.52 m focus-film distance. The exam was in accordance to the radioprotection protocol (resolution 453 of 06/01/1998, Brazilian Health Ministry).

The variables were measured manually by a single examiner. Twenty radiographs were randomly selected for a second analysis after 1 week in order to verify the cephalometric trace reliability.

The anatomical points used in the cephalometric analysis are described in Figure 1. The angles and lines traced from these points are shown in Chart 1.

Chart 2 describes the cephalometric variables: five related to the craniocervical posture[3,12-13], one related to the mandibular position[12] and three related to the hyoid bone position[14].

In order to investigate the influence of the craniocervical posture on the mastication and swallowing functions, the cervical curvature and the flexion/extension head position were interpreted based on their reference values. The forward head posture was classified in more or less accentuated.

Fig. 1 - Anatomical points used in the cephalometric analysis: ANS – anterior nasal spine; PNS– posterior nasal spine; N (nasion) –anterior point at fronto-nasal suture; S (Sella) – center of sella turcica; H – most anterosuperior point of the Hyoid bone; O – basi-occiput; RGn (retrognathion) – the most inferior posterior point at the mandibular symphysis; Me (Mentum) – most inferior point at the mandibular symphysis; CV2tg - the tangent point at the superior posterior extremity of the odontoid process of the second cervical vertebra (C2); CV2ip - the most infero-posterior point on the body of the second cervical vertebra; CV2Ap – tangent point to the apex of the C2 dente;; CV2ia - the most infero-anterior point on the body of the second cervical vertebra; CV3ai – the most anterior inferior point on the body of the third vertebra; CV4ip - the most infero-posterior point on the body of the fourth cervical vertebra; CV6ip - the most infero-posterior point on the sixth cervical vertebra; Ce1 a Ce7 – central points of the vertebral bodies from C1 to C7.

Chart 1 – Lines and angles of the cephalometric analyisis of the cranicocervical posture and the mandibular position.

Line	Definition
NSL	Nasion-sella line - between N and S
OPT	Odontoid Process Tangent - between CV2tg and CV2ip
CVT	Cervical Vertebra Tangent - between CV2tg and CV4ip
EVT	Lower part of the cervical spine - between CV6ip and CV4ip
ML	Mandibular line - Tangent to the lower border of the mandible through Gn
Angle	**Definition**
CVA	Intersection of the lines between O - ANS- PNS and CV2Ap - CV2ia
CPL	Intersection line between Ce1 to Ce6 with the horizontal

Chart 2 – Cephalometric variables related to the craniocervical posture and mandibular and hyoid position

Craniocervical	Postural Variables
NSL/CVT	Cranium inclination in relation to the cervical spine (C2 – C4)
NSL/OPT	Cranium inclination in relation to C2
CVT/EVT	Cervical lordosis
CVA	Head flexion/extension
CPL	Forward head
Hyoid bone and mandible position	
NSL/ML	Cranium basis inclination in relation to the mandible
Hy/C3	Hyoid to third cervical vértebra distance
Hy/Me	Hyoid to mentum distance
Hy/ML	Hyoid to the mandibular plane

The relation of the cervical curve was obtained from the hyoid triangle trace. The triangle consists in the union of the CV3ai - RGn, CV3ai - H, and H – RGn points (Chart 1). The curve is determined by the hyoid position in relation to the CV3ai – RGn line: hyoid placed till 5 mm bellow this line refers to the physiological cervical lordosis, hyoid on the line means cervical rectification and above this line it corresponds to curve inversion[3].

The craniovertebral angle (CVA) classifies gradually the anteroposterior cranium position related to the cervical column: CVA from 96 to 106° corresponds to the normal head posture, smaller than 96° corresponds to the head extension and greater than 106° corresponds to the head flexion[3].

Based on the CPL angle[9], the subjects were classified according to more (CPL < 80°) or less (CPL > 80º) accentuated forward head posture.

The evaluation of the masticatory and swallowing functions was based on the Orofacial Myofunctional Evaluation Protocol with Scores (AMIOFE)[15] and was conducted by a single qualified speech therapist. Both functions were tested with bread. Particularly in the swallowing function evaluation, water was also offered to the volunteers during the exam.

In the swallowing evaluation, the labial occlusion with effort or the absence of the oral cavity sealing was considered atypical, while the labial occlusion with no effort was considered typical. Tongue interposition between the dental arches corresponds to the atypical pattern. The tongue contained in the oral cavity in contact with the hard palate during swallowing action was considered as typical. Other evaluated signs of alterations were the presence of the head movement and the facial muscle tension during the function.

Concerning the masticatory function, the atypical pattern is characterized when it is carried out in both sides of the occlusal surfaces, that is, bilateral vertical mastication. The alternated way characterizes the typical pattern. When the mastication is carried out in only one side, it is classified as unilateral chronic or preferential, considered as atypical or typical pattern, respectively. Signs of alteration in the mastication function such as the presence of the head movements and/or altered head posture were also evaluated.

The intraclass correlation coefficient (ICC) verified the reliability of the cephalometric measurements. The ICC values should be greater than 0.75 to indicate good reliability and those below 0.75 indicate poor to moderate reliability[16].

In order to verify de data normality, the Lilliefors test was used in the angular and linear cephalometric variables. The correlation between the cephalometric variables related to the craniocervical posture and the variables related to the mandibular and hyoid position was tested by the Pearson's coefficient (r). Based on the coefficient value, the correlation was considered strong for $r \geq 0.7$; moderate for $0.3 < r < 0.7$, and weak for $0 < r < 0.3$[17]. A descriptive statistical verifies the subject percentage in each group, according to the number of craniocervical postural changes and the aspects evaluated in the masticatory and swallowing functions. The chi-square test analyzed the difference of the percentage between the groups. It was admitted a significance level of 5% ($p<0.05$).

Results

The study evaluated 36 women with mean age of 23.77 ± 3.47 years and BMI of 22.61 ± 4.38 kg/cm^2.

Figure 2 presents the results related to the craniocervical postures based on the cephalometric analysis.

It was verified that 86.11% of the subjects presented changes in the cervical curve, 77.78% with cervical lordosis rectification. Changes in the head position related to the upper cervical spine were observed in 47.23% of the subjects, 30.56% presenting head hipextension. The forward head was more acentuated in 41.67% of the subjects.

ICC results demonstrated excelent reliability in all measured angles by the same examiner in two distincts moments, as shown in Table 1.

Correlations between the craniocervical variables and the ones that assessed the mandible and hyoid position are presented in Table 2.

From these results, it can be inferred that the head hyperextension was correlated to a greater distance from the hyoid bone to the mandible and to the mentum. The more forward head position also influenced the hyoid bone to the mandible distance.

A negative correlation between the cervical curve and the distance between the hyoid bone and the third cervical vertebra (C3) was observed. Thus, the more rectified the cervical column, the more away the hyoid to the C3.

The degree of the cranium base inclination on the cervical column in two levels (NSL/OPT and NSL/CVT) presented positive correlation with the distance from the hyoid bone to the mentum, to the mandible and to the C3. These were the only variables that obtained a significant correlation with the mandibular position (NSL/ML).

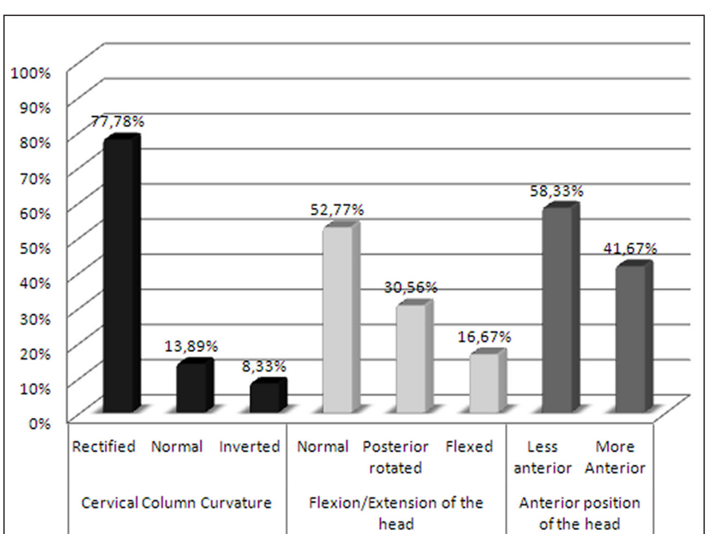

Fig. 2 - Frequency of postural changes found in the study group based on the cephalometric analysis.

Table 1 - Intra-examiner reliability of the cephalometric measurements

Angles	ICC	Confidence Interval	p
NSL/CVT	0.986	0.964 – 0.955	0.00*
NSL/OPT	0.994	0.986 – 0.998	0.00*
CVT/EVT	0.979	0.947 – 0.992	0.00*
CVA	0.995	0.987 – 0.998	0.00*
CPL	0.901	0.754 – 0.960	0.00*
NSL/ML	0.918	0.797 – 0.967	0.00*
Hy/C3	0.994	0.984 – 0.997	0.00*
Hy/ML	0.990	0.976 – 0.996	0.00*
Hy/Me	0.990	0.975 – 0.996	0.00*

CVA: Craniovertebral angle; CVT/EVT: cervical spine curve; CPL: angle related to the forward head posture; NSL/OPT: Cranium inclination in relation to the C2; NSL/CVT: Cranium inclination in relation to the cervical spine ; Hy/C3: Hyoid bone to the third cervical vertebra distance; Hy/Me: Hyoid to mentum distance; Hy/ML: hyoid to mandibular plane distance; NSL/ML: Cranium inclination in relation to the mandible; n=20.

Table 2 - Correlation between craniocervical posture and the mandible and hyoid bone position

Measurements	NSL/ML	Hy/Me	Hy/ML	Hy/C3
NSL/OPT	0.38*	0.40*	0.34*	0.32*
NSL/CVT	0.42*	0.41*	0.36*	0.33*
CVT/EVT	-0.23	0.30	0.12	-0.40*
CVA	-0.27	-0.48*	-0.45*	-0.34*
CPL	-0.23	-0.17	-0.51**	-0.11

CVA: Craniovertebral angle; CVT/EVT: cervical spine curve; CPL: angle related to the forward head posture; NSL/OPT: Cranium inclination in relation to the C2; NSL/CVT: Cranium basis inclination in relation to the cervical spine; Hy/C3: Hyoid bone to the third cervical vertebra distance; Hy/Me: Hyoid to mentum distance; Hy/ML: hyoid to mandibular plane distance. n= 36. Results expressed in r (Pearson's coefficient correlation) *$p<0.05$; **$p<0.01$

All the subjects presented at least one postural change, both in the flexion/extension and forward head position and in the cervical curve. Therefore, it was not possible to analyze the association between the presence or absence of craniocervical postural changes and the masticatory and deglutition functions. For the statistical analysis, the subjects were classified as presenting i) only one or ii) two and three postural changes (Table 3). Regarding the masticatory function, the unilateral chronic and preferential patterns were grouped, once only one subject presented the chronic pattern.

As demonstrated in Table 3, there was no association between more accentuated changes in the craniocervical posture and the changes and the masticatory and deglutition functions, evaluated in the myofunctional orofacial evaluation.

Regarding the deglutition function, the changes more frequently observed were: effort in the lip occlusion (16.66% of the subjects) and facial muscle tension (19.44% of the subjects). In the masticatory function, the bilateral simultaneous pattern was not observed. Therefore, the pattern was typical, that is, alternated in all subjects with bilateral pattern. The unilateral pattern was observed in 52.77% of the subjects.

Table 3 - Presence of craniocervical posture changes (1 or 2 and 3) and its relationship with the masticatory and swallowing function evaluations

		1 AlteratioN (n = 16)		2 and 3 Alterations (n = 20)		
		f	%	f	%	p
Lips occlusion during the deglutition	typical	13	81.25	17	85	0.57
	with effort	3	18.75	3	15	
Tongue posture during the deglutition	typical	15	93.75	20	100	0.42
	Interposed	1	6.25	0	0	
Head moviment during deglutition	Absent	15	93.75	18	90	0.53
	Present	1	6.25	2	10	
Facial muscles tension during deglutition	Absent	13	81.25	16	80	0.61
	Present	3	18.75	4	20	
Masticatory Pattern	Bilateral alternate	8	50	9	55	0.54
	Unilateral preferential or chronic	8	50	11	45	
Head Moviment during mastication	Absent	16	100	19	95	0.56
	Present	0	0	1	5	
Altered head posture during mastication	Absent	16	100	18	90	0.32
	Present	0	0	2	10	

Craniocervical posture changes: forward head position, flexion/extension head and cervical curve altered,(1) presence of one of these changes; (2 to 3) presence of 2 and/or 3 changes. Chi-square test * p<0,05

Discussion

All studied subjects presented at least one postural deviation in the craniocervical segment. The modification of the physiological lordosis curve was the most evident postural alteration, since 86.11% of the subjects presented some type of deviation such as rectification or inversion of the curve.

The presence of significant postural changes has been observed, particularly, in working subjects, who are more vulnerable to the postural bad habits and vicious. The decrease in the cervical lordosis was previously described in subjects at the same age of this study and the authors alert for this severe postural deviation expressed in so young subjects[18].

From the correlation analysis, it was verified that head hyperextension was correlated with a greater distance from the hyoid bone to the mandible and to the mentum. Other studies presented similar results, demonstrating significant correlation between the craniovertebral angle with the greater distance in Hy/ML[19-21] and Hy/Me[19,21].

A more accentuated forward posture was also correlated to a greater Hy/ML distance, possibly because this is a change that usually follows the cranium hyperextension in order to keep the optical plane in the horizon. However, it puts the mandibular symphysis in a more elevated position.

Moreover, considering the negative correlation among CPL and CVA angles with the Hy/ML distance observed in this study, we can infer that in the presence of a forward and extend head posture a major effort by the suprahyoid muscles will be necessary to pull the hyoid bone and larynx upward and forward during swallowing function, allowing the pharyngoesophageal sphincter to open with guarantee of no food aspiraton[22].

Muto et al.[21] (2002) showed that the Hy/C3 distance stayed constant regardless the cranium position. On the other hand, Özbek et al.[20] (1998) found a significant correlation between the forward head and the cranium hyperextension with the increase of the Hy/C3 distance, similar to the negative correlation between this distance and craniovertebral angle observed in the present study.

The relationship between the craniocervical posture and the hyoid bone can be the reflex of the tongue position in the oral cavity. The hyoid bone serves as anchor to the tongue musculature, thus its lower position tractions the tongue to a lower and back position reducing the airway space. In face of the vital need of keeping this space, the craniocervical postural change acts as compensatory mechanism, pulling the hyoid bone far from the posterior pharyngeal wall (increasing the Hy/C3 distance) in order to guarantee the airway permeability[20].

The cranium inclination on the cervical column in two levels (NSL/CVT and NSL/OPT) presented a moderate and significant correlation with the hyoid bone distance from the hyoid bone to the mentum, also previously found in the literature[21]. Additionally, there were moderate correlations with the Hy/ML and Hy/C3 distances, in disagreement with another studies[20,23].

NSL/CVT and NSL/OPT were the only variables to show a significant correlation with the mandibular position (NSL/ML). Such finding illustrates the interdependence between the structures that composed the biomechanical unit represented by the craniocervicomandibular system[2].

Taking into account that the main muscles that displace the hyoid bone (mylohyoid and geniohyoid muscles) originate in the mandible, the length-tension relation of these muscles are affected by the mandible position, interfering directly on the stomatognathic functions[7].

The changes in hyoid bone position can be also correlated to the cervical curve, once the supra and infrahyoid muscles act as antagonist of the posterior cervical muscles that maintain the physiological cervical lordosis. A higher position of the hyoid can be related to the rectification and inversion of this curvature[3]. In the present study, the positive correlations between CVT/EVT and Hy/Me and Hy/ML are in accordance with this reasoning, since curve rectification was correlated with the smaller distance from the hyoid to the mandible and to the mentum. However, such correlations were weak and had no statistical significance.

For Hellsing[19] (1989), the cervical curve rectification was correlated to the lower position of the hyoid bone, nevertheless the correlations, as in the present study, were not significant. Similarly, we observed that the hyoid position related to C3 was the same in one group of young subjects, despite the reduction of the cervical lordosis[18].

In the present study, there was a significant correlation only between CVT/EVT and Hy/C3, with a trend to the rectification and inversion of the cervical curve in a presence of a greater distance Hy/C3. A greater muscle tension in the supra and infrahyoid muscles, together with the other muscles of the anterior chain, tend to produce the cervical rectification. Thus, the hyoid bone may be pulled to a more anterior position, increasing the distance Hy/C3.

Kollias and Krosgstad[24] (1999) observed that the forward head posture was followed by a reduction of the physiological lordosis and in the pharyngeal airway space, probably due to the approximation of the tongue to the posterior pharyngeal wall. Thus, in addition to the relation of postural biomechanical, the increase in the Hy/C3 may occur in the attempt of opening the airway by the hyoid traction, due to its relation with the tongue base.

Since the anatomical relation among cranium, cervical column, mandible and hyoid bone was confirmed, we hypothesized that craniocervical posture changes could intervene in the stomatognathic functions. However, no association was found between a greater misalignment in the craniocervical posture and atypical behavior during masticatory and swallowing functions.

Silva et al.[25] (2004) conducted a similar study with 15 subjects evaluated by anthroposcopic analysis. The authors also observed that all subjects presented at least one postural change in the craniocervical segment. Additionally, they could not demonstrate a significant association between changes in the craniocervical posture and in the stomatognathic system. Nevertheless, 60% of the studied subjects presented alteration in the anterior muscular chain and in the masticatory function.

Harmony and balance between form and function are determinant features for a healthy condition of the stomatognathic system, which in turn leads to typical orofacial behaviors during alimentary functions performance[1]. On the other hand, in face of a structural alteration, the functions may be maintained through compensatory actions, a mechanism found by the body to perform the masticatory and swallowing functions. This can, partially, explain the fact that, despite the craniocervical posture changes present in all studied subjects, those were not associated to myofunctional orofacial changes.

In summary, to understand how the body can adapt itself in such situations, it must be borne in mind a human body entirely composed by muscular chains, which are dependent one for each other. It has been described models explaining myofascial trains and sequences comprising myofascial connections crossing the entire body. These trains are directly involved in the organization of movements and function as well as muscular force transmission[26].

It is well known, that a prolonged altered head posture may lead to asymmetric electromyography (EMG) activity in the jaw muscles. On the other hand, symmetry of the EMG activity of the masticatory system may be a contributing factor for the appropriate development of physiologic functions such as mastication, deglutition, respiration, and speech. Thus, to reach a more symmetrical EMG activity of these muscles and typical mandible and hyoid movements, patients may continuously adopt postural compensations at the level of the craniocervical segment[27].

Supporting this reasoning, Douglas et al.[28] (2010) stated that when some kind of disturb intervene on the motor control of the stomatognathic system, the body adapts in order to keep functions performing perfectly. However, it occurs up to the point that the adaptive reactions become insufficient to transpose the system fails. In this case, the functions will suffer the effects of the signals and symptoms of a stomatognathic disorder such as TMD, previously related to the atypical behaviors of the mastication and swallowing[29]. Thus, it is possible that the atypical behaviors were less evidenced in this study because the presence of TMD was an exclusion criterion.

In this study, it is assumed that the postural changes not influenced the alimentary functions due to the possibility of the organism adapts itself to the structural conditions. Based on this, it must be adverted that the craniocervical posture evaluation is not neglect in the orofacial motricity assessment, and the reciprocal is true as well. Such approach provides not only therapeutics but also prophylactic intervention in these cases.

It must be mentioned that, despite the important postural changes observed in the subjects of the present study, none of them had undergone physical therapy treatment for postural training. In the same way, they were not previously undergone to speech therapy, even with atypical behavior in the alimentary functions. Therefore, this study is relevant in disclosing for theses participants, the need of these therapeutic interventions to improve the performance of the postural and stomatognathic systems.

In the studied subjects, it was observed at least one postural deviation on the craniocervical segment, with predominance of rectification and inversion of the cervical curvature.

In conclusion, cephalometric findings confirmed the anatomical relationship between craniocervical posture, mandible and hyoid bone. However, the association between craniocervical posture alterations and masticatory and swallowing function impairments was not observed. Such findings suggest that, in the presence of a musculoskeletal imbalance, the body readapts itself, ensuring that alimentary functions will not be affected.

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