EVALUATION OF SEXUAL DIMORPHISM AND THE RELATIONSHIP BETWEEN CRANIOFACIAL, DENTAL ARCH AND MASSETER MUSCLE CHARACTERISTICS IN MIXED DENTITION

Avaliação do dimorfismo sexual e da relação entre as características craniofaciais, dos arcos dentários e do músculo masseter na fase de dentição mista

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ABSTRACT

Purpose: to evaluate sexual dimorphism and the relationship between craniofacial characteristics, dental arch morphology and masseter muscle thickness in children in the mixed dentition stage. **Methods:** the study sample comprised 32 children, aged 6-10 years (14♀/18♂) with normal occlusion. Craniofacial characteristics, dental morphology and masseter muscle thickness were evaluated by means of posteroanterior cephalometric radiographs, dental cast evaluation and ultrasound exam, respectively. The results were analyzed using Shapiro-Wilk test, Mann-Whitney/*t*-test and stepwise linear regression to assess the relation between *face width* and age, gender, body mass index, masseter thickness, distances between first molars and canines on dental casts (between cusps/ cervical points), nasal, maxillary, mandibular and intermolar widths. **Results:** masseter thickness showed no significant difference between the sides left/right. The comparison between genders showed significant difference only in *face width*, being larger in boys. The regression model showed that *face width* was positively related with body mass index, masseter thickness, mandibular first molar distances (cusps), mandibular canine distances (cervical points), and maxillary intermolar width; and negatively with maxillary (cusps) and mandibular molar distances (cervical points) and mandibular canine distances (cusps). That is, when the other studied variables were considered, the explanatory variable *gender* did not reach a significant value. **Conclusion:** in the studied sample, the dimensions of the dental arches and masseter thickness did not differ between boys and girls; moreover, *face width* showed significant relationship with body mass index, masseter thickness, and dimensions of dental arches; but *gender* did not contribute significantly to *face width* variation.

KEYWORDS: Masseter Muscle; Child; Sex Characteristics; Dental Occlusion; Face

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■ INTRODUCTION

In mastication, there is well integrated neuromuscular activity, which occurs simultaneously with a synchronous contraction of muscles during closing, opening, laterally and mandibular protrusion. As occlusion and mastication mature, the anatomy of all articular components is modified to adapt to new patterns of changes in occlusion, occlusal guides, fossa depth and cusp height[1]. Many factors such as heredity, bone growth, eruption and inclination of teeth, environmental influences, and function affect changes in the size and shape of dental arches[2].

The quality of masticatory function is dependent on a number of factors such as occlusal area, number of teeth, activity, size and coordination of masticatory muscles and craniofacial dimensions, and action of the tongue and perioral muscle in handling food[3]. It is known that brachycephalic individuals are characterized by lower anterior facial height, lower slope of the mandible, less obtuse gonial angle and parallelism between the palatal and mandibular planes. Functionally, these individuals present greater masticatory muscle thickness[4] and higher bite force[5-7]. It is well known that the adult male skull has higher angularity, size, bone thickness, cranial capacity and lower orbits; moreover, it has less vertical length, that is, lower values for height/width face index[8]. In the mandible, the internal and external reliefs are shaper and have a less obtuse gonial angle. However, previous studies have reported that in children, differences in craniofacial morphology between boys and girls become significant after eight years of age[9-11].

In the study of transversal dimensions, the posteroanterior cephalometric radiograph (PA) has shown to be important and reliable[12-14], but it has not yet become routinely used in dental practice, since lateral cephalometric study is still the most used method. Thus, the use of accurate and reproducible methods for measuring craniofacial anatomical structures is the best way to understand the interplay between form and function[15-17].

Therefore, the aim of this study was to evaluate sexual dimorphism and the relationship between craniofacial characteristics, dental arch morphology and masseter muscle thickness by means of posteroanterior cephalometric radiographs (PA), dental cast evaluation and ultrasound exam, respectively, in children with normal occlusion, in the mixed dentition stage.

■ METHODS

The study sample consisted of 32 children of both genders (14 girls and 18 boys) aged 6–10 years, who were to start dental treatment at the Department of Pediatric Dentistry, Piracicaba Dental School, Piracicaba, Brazil. The children and their parents consented to participate in the study, and the research was approved by the Ethics Committee of the Piracicaba Dental School (Protocol No. 023/06). The sample was selected after a complete anamneses and clinical examination, verifying a healthy state, the presence of all teeth without anomalies and alterations of form, structure or number, and the normality of oral tissues. Children with dental caries and/or restorations that could compromise tooth dimensions, systemic disturbances, signs and symptoms of temporomandibular joint dysfunction and history of orthodontic treatment were excluded. Body weight and height were determined, and the body mass index was calculated as: $BMI = Kg/m^2$.

Only children with normal dental occlusion, in the mixed dentition stage (intermediate period) were selected, taking into account the following parameters: first molars and incisors erupted and occluded; presence of primary molars and canines; molar Angle's Class I – the mesiobuccal cusp of the maxillary first molar occluding in the mesiobuccal groove of the mandibular first molar; normal range for overjet up to 4.0 mm and normal range for overbite up to 3.5 mm. Children with crowding, midline deviation or transversal discrepancy were also excluded[18].

For the impression takes the subjects were sitting in an upright position with the head in natural position. The points were marked on dental casts with pencil edge 0.3 mm and the linear distances were measured by digital caliper[18] (Digimatic series 500, Mitutoyo, Japan) to the nearest 0.01 mm by one examiner (MCSM). The distance between the mesiolingual cusp tips of the first molars and cusp tips of the canines were measured (or the estimated location if wear facets were present). In addition, the linear distances between the inner lingual points on the gingival margin of the right and left first molars and canines were measured (cervical point).

The cephalometric tracings were performed by the determination of points and linear distances on frontal radiographs, which were hand traced on acetate paper and measured using a digital caliper (Digimatic series 500, Mitutoyo, Japan) to the nearest 0.01 mm. The following measurements were recorded[14,19]: face width (ZA-AZ) – distance between the bilateral points to the center of the root of the zygomatic arch; mandibular width (GA-AG) – distance between right and left points at lateral inferior margin of antegonial protuberances; maxillary width (JR-JL) – distance between the jugal process at the intersection of outline of the

maxillary tuberosity and zygomatic buttress; nasal width – distance between the inner cortical borders of the nasal cavity; maxillary and mandibular inter-molar width – linear measurement between the most prominent lateral point on the buccal surface of the maxillary and mandibular first molars, respectively. The determination of points, landmarks and measurements were done by the same examiner (ASA).

The masseter muscle thickness was measured bilaterally by ultrasound examination (Just Vision Toshibaä, 56 mm/10 MHz linear transducer, Otawara, Japan), by the same examiner (MR). Briefly, children were seated in an upright position with their heads in natural position; recordings were performed with the muscle relaxed (at rest) and in maximal intercuspal position. The measurements were determined three times, directly on the screen (accuracy of 0.1 mm), and the values averaged.

Images were taken on both sides (left and right) and the recording site was established by palpation, between the zygomatic arch and gonial angle. The transducer was placed perpendicular to the muscle fiber direction, using an air-tight inert gel on the skin surface, and moved gradually to obtain optimal visualization[17].

The error of measurement (ME) for dental cast measurements and masseter ultrasonographic thickness evaluation was assessed by repeated measurements of 12 subjects (n), on two separate occasions (m1, m2), using the Dahlberg's formula: $S_e = \ddot{O}\sum (m1 - m2)^2 / 2n$. The results are shown in Table 1. The reproducibility of tracings and measurements performed on PA radiographs was assessed by correlation coefficients, which were repeated on 15 radiographs. All the coefficients obtained showed perfect reproducibility (r = 1.00).

Table 1 – Values obtained for the measurement error (ME) analysis of dental cast measurements and masseter ultrasonographic thickness of 12 subjects assessed by repeated measurements on two separate occasions

ME	1st maxillary molars width (mm)		1st mandibular molars width (mm)		Masseter thickness (mm)	
	cusp-cusp	cerv-cerv	cusp-cusp	cerv-cerv	MRE	MMI
	0.30	0.36	1.23	0.11	0.35	0.31

cusp, cusp; cerv, cervical point; MRE, masseter thickness at rest; MMI, masseter thickness at maximal intercuspal position; mm, milimeters.

Statistical analysis was performed using Sigma Stat (3.1 Sigma Stat Software Inc., Richmond, CA, USA) and BioEstat 5.0 (Mamirauá, Belém, PA, Brazil) with a 5% level of significance, and normality was assessed using the Shapiro-Wilk *W*-test.

A paired *t*-test was used to evaluate the difference in masseter muscle thickness between the sides (left/right). Unpaired *t*-test or Mann-Whitney test was used to analyze the differences in age, BMI, measurements of dental casts and craniofacial variables and masseter thickness between genders, were appropriate. Moreover, a multiple linear regression model with backward stepwise elimination was used to verify the relationship between *face width* (as the dependent variable) and age, gender, BMI, dental cast measurements, masseter

thickness at rest and maximal intercuspation and posteroanterior cephalometric variables.

■ RESULTS

The characteristics of the sample according to age, BMI, measurements of dental casts, craniofacial variables and masseter thickness are shown in Tables 2 and 3. Masseter muscle thickness at rest and maximal intercuspal position did not differ significantly between the left and the right sides in both groups. Sexual dimorphism was tested for all studied variables. Only the variable *face width* showed significant difference between genders, being larger in boys (*P*=0.0012), when comparison was made with a *t*-test.

Table 2 – Mean (±SD) for age, body mass index and measurements of dental casts for both groups

Gender	Age (months)	BMI (Kg/m²)	Maxillary canines distance (mm)		Mandibular canines distance (mm)		1st maxillary molars distance (mm)		1st mandibular molars distance (mm)	
			cusp-cusp	cerv-cerv	cusp-cusp	cerv-cerv	cusp-cusp	cerv-cerv	cusp-cusp	cerv-cerv
Female	101.00 (±12.74)	18.46 (±3.12)	33.46 (±1.57)	26.20 (±1.44)	26.71 (±1.65)	21.30 (±1.82)	41.67 (±1.84)	34.35 (±1.39)	36.39 (±2.72)	33.68 (±2.59)
Male	100.39 (±14.43)	17.03 (±2.21)	33.64 (±1.62)	26.38 (±1.68)	26.29 (±1.37)	20.93 (±1.43)	41.44 (±2.12)	33.89 (±2.07)	35.77 (±1.46)	32.8 (±1.33)

P>.05 (*t* test or Mann Whitney Rank Sum test)

BMI, body mass index; mm, milimeters; cusp, cusp; cerv, cervical point.

Table 3 – Mean (±SD) for the thickness of the masseter muscle and craniofacial measurements on posteroanterior cephalograms for both groups

Gender	MRE (mm)	MMI (mm)	AZ-ZA (mm)	AG-GA (mm)	JL-JR (mm)	Nasal width (mm)	Maxillary intermolar width (mm)	Mandibular intermolar width (mm)
Female	15.21 (±1.21)	18.11 (±1.80)	113.53*** (±5.44)	76.60 (±3.90)	58.78 (±3.48)	25.77 (±1.36)	55.54 (±3.95)	54.99 (±4.39)
Male	15.59 (±2.55)	18.03 (±2.50)	121.48*** (±6.73)	77.12 (±4.28)	58.72 (±3.40)	26.14 (±1.87)	57.42 (±2.96)	55.24 (±2.12)

***$P<0.001$ (*t* test; t=-3.598; 30 degrees freedom; CI = −12.464 to −3.438; power = 0.93).

mm, milimeters; MRE, masseter thickness at rest; MMI, masseter thickness at maximal intercuspal position; AZ-ZA, face width; AG-GA, mandibular width; JL-JR, maxillary width.

Because muscle thickness did not differ between right/left sides, it was decided to consider the average between the two in the multiple regression analysis. The results of the regression analysis (Table 4) showed that *face width* positively and significantly correlated with BMI, masseter thickness, first mandibular molar distances (between cusps), maxillary canine distances (between cervical points), and maxillary intermolar width; and negatively with first maxillary (cusps) and mandibular molar distances (cervical points) and mandibular canine distances (cusps). However, the explanatory variable ***gender*** did not reach a significant value*.* The model used explained almost 55% of *face width* variability, considering the sample size (coefficient of determination R^2 = 0.547), with a power of 1.00.

Table 4 – Multiple linear regression model with backward stepwise elimination used to verify the relationship between *face width* (as the dependent variable) and BMI, age, dental cast measurements, masseter thickness at rest and maximal intercuspation and posteroanterior cephalometric variables, controlling for gender (those variables eliminated from the model are not shown)

Dependent variable	Independents variables	Coeff	*P*-value	Significance of the model		
				R² adjusted	*P*-value	Power of the test
Face width (AZ-ZA)	Constant	-21.282	-	0.547	0.001	1.000
	BMI	169.232	0.001			
	1st Maxillary molars distance (cusps)	-3.338	0.004			
	1st Mandibular molars distance (cusps)	6.159	0.023			
	1st Mandibular molars distance (cervical points)	-20.672	0.004			
	Maxillary canines distance (cervical points)	3.465	0.003			
	Mandibular canines distance (cusps)	-3.757	0.002			
	MMI	9.761	0.004			
	Maxillary intermolar width	1.218	0.009			
	Gender	4.837	0.179			

Multiple linear regression model with backward stepwise elimination
BMI, body mass index; MMI, masseter thickness at maximal intercuspal position

■ DISCUSSION

The dental, skeletal and muscle evaluation may contribute to the study of the relationship between form and function of the structures that comprise the stomatognathic system, and also provide the establishment of an appropriate treatment plan. Posteroanterior analysis provides an assessment of transverse dimensions of the face, making it possible to obtain a broader vision for the diagnosis of changes[20]. Moreover, dental casts have frequently been used in diagnosis, planning and evaluation of established treatment[21,22]. The use of both intercanine distance between cusp tips and between cervical points is justified because the latter distance is more reliable and less susceptible to tooth inclination. But the use of ultrasound in scientific research provides reproducible and easy access to the masticatory muscles thickness, obtaining quantitative information on functional ability and determination of structural changes[17], without the subject's exposure to radiation.

In the present study, there were no significant differences in dental cast measurements between genders. In adolescents and young adults, previous studies have also found no differences in dental arch measurements between men and women[23,24].

However, in a large sample of children with primary dentition, boys were shown to have larger dental arches than girls, and this difference was high and statistically significant[25]. Moreover, sexual dimorphism in arch dimensions was observed in the mixed dentition stage[25]; but after a longitudinal observation until permanent dentition, they observed no sexual dimorphism in dimensional changes.

In addition, there were no significant difference in masseter thickness between boys and girls. However, a past study[23] which included older subjects aged 7-18 years observed direct and significant association between masseter thickness and age and gender; that is, the masseter muscle was thicker in older individuals and in males. Similar results were also observed previously[26]; groups of males with skeletal Class I and skeletal Class II had thicker masseter muscles in comparison with females. However, it should be noted that individuals who comprised the present study were children aged up to 10 years, i.e. before the pubertal growth phase, which is believed to be the period of greatest muscle development, especially among boys[5]. Moreover, masseter muscle thickness did not differ significantly between the left and the right sides in both groups, which was expected since the

studied sample included only children with normal occlusion[17].

When considering the craniofacial morphology, there is a consensus in the literature that in a normal population male subjects have larger skeletal, cranial and facial dimensions than female subjects[27]. These differences may also manifest in the dimensions of the jaws and their relations among them[28]. When data for *face width* were compared between boys and girls using the comparison of means, the present study showed that *face width* was larger in boys than in girls in young subjects with mixed dentition. This finding corroborates studies in young children, in which the authors observed that sexual differences in craniofacial morphology become significant after eight years of age[9-11]. The other craniofacial measurements, maxillary, mandibular and nasal widths, did not differ significantly between genders.

But when the relationship between *face width* and the various dental, craniofacial and masseter muscles variables was evaluated, the results showed that *face width* was positively correlated with BMI, masseter thickness, first mandibular molars distance (between cusps), maxillary canines distance (between cervical points) and maxillary intermolar width, but not significantly with gender. As previously observed[23], wider maxillary arch followed larger masseter muscle thickness in young females, which suggests that the thickness of masseter muscle should be considered as one of the factors affecting facial morphology. Significant correlation between masseter muscle thickness and craniofacial morphology was also reported previously[26]. The mentioned study reported a significant negative correlation between muscle thickness in the contracted state and mandibular plane angle, i.e., individuals with thicker masseter had a shorter vertical facial pattern. According to the statistical analysis used and corroborating those previous studies, *face width* was closely related to BMI, dental arch morphology and to the attached muscle, but not to the explanatory gender.

Face width related negatively with first mandibular molar distances (between cervical points) and mandibular canine distances (between cusps), showing that the width of the face obtained from PA cephalograms follows the maxillary width, and was negatively related with mandibular width. Furthermore, *face width* was negatively related with first maxillary molar distances (between cusps), but this contradictory result may be due to a possible palatal inclination of these teeth, since the measurement obtained between cusps is less reliable than that taken between cervical points.

Evaluation of the structures that comprise the stomatognathic system may contribute to the study of their relationship, the impact on occlusal and dental health, and also provide the establishment of an appropriate treatment plan in young subjects[4,9,12,29]. The inclusion and exclusion criteria limited the sample size, being the limitation of this study. Thus, further studies are required to investigate the relationship between dental, muscular and craniofacial characteristics in young subjects in a larger sample.

■ CONCLUSIONS

In the studied sample, the dimensions of the dental arches and masseter muscle thickness did not differ between boys and girls in mixed dentition with normal occlusion.

Moreover, the width of the face was significantly related with body mass index, masseter thickness, and the dimensions of the dental arches; but *gender* did not contribute significantly to *face width* variation.

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RESUMO

Objetivo: avaliar o dimorfismo sexual e a relação entre as características morfológicas craniofaciais, dos arcos dentários e do músculo masseter na fase de dentição mista. **Métodos:** 32 crianças, com idade entre 6-10 anos (14♀/18♂) com oclusão normal, compuseram a amostra. Características morfológicas craniofaciais, dos arcos dentários e espessura do masseter foram avaliadas por meio de radiografia cefalométrica posteroanterior, modelos em gesso e ultrassonografia, respectivamente. Os resultados foram analisados utilizando testes Shapiro-Wilk, Mann-Whitney/teste "t" e regressão linear múltipla para avaliar a relação entre a *largura da face* e idade, gênero, índice de massa corporal, espessura do masseter, distâncias intermolares e intercaninos (entre cúspides e pontos cervicais) e larguras nasal, maxilar, mandibular e intermolar. **Resultados:** a espessura do masseter não diferiu significativamente entre os lados esquerdo e direito. A comparação entre os gêneros mostrou diferença significativa apenas na *largura da face* (maior em meninos). O modelo de regressão mostrou que a *largura da face* relacionou-se positivamente com o índice de massa corporal, espessura do masseter, distâncias intermolares (cúspides) e intercaninos (cervicais) inferiores e largura intermolar maxilar; e negativamente com a distância intermolares superiores (cúspides) e inferiores (cervicais) e intercaninos inferiores (cervicais). Ou seja, quando as demais variáveis foram adicionadas ao modelo, a variável explanatória *gênero* não alcançou valor significativo. **Conclusão:** na amostra avaliada, a espessura do masseter e dimensões dos arcos dentários não diferiram entre gêneros; além disso, a largura da face mostrou relação significativa com o índice de massa corporal, espessura do masseter e dimensões dos arcos dentários, mas o gênero não contribuiu significativamente para sua variação.

DESCRITORES: Músculo Masséter; Criança; Características Sexuais; Oclusão Dentária; Face

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