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Muscle thickness, bite force, and craniofacial dimensions in adolescents with signs and symptoms of temporomandibular dysfunction

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SUMMARY Ultrasonography has been used to determine the association between muscle thickness, temporomandibular dysfuntion (TMD), facial morphology, and bite force. The aim of this study was to evaluate signs and symptoms (SS) of TMD using the craniomandibular index (CMI), masseter and anterior temporalis thickness, facial dimensions, and bite force in adolescents (12–18 years of age): 20 (10 males and 10 females) with SSTMD and 20 without (control, matched for age and gender). Ultrasonography was carried out using Just-Vision 200, and bite force measured with a pressure transducer. The measurements undertaken on the cephalograms included anterior (n-gn, n-Me, sp-gn) and posterior (S-tgo) facial dimensions, jaw inclination (NSL/ML), vertical jaw relationship (NL/ML), gonial angle (ML/RL), and overbite and overjet. The data were analysed with analysis of variance, Pearson's and Spearman's correlation and multiple regression.

The SSTMD group showed a smaller bite force than the controls ($P < 0.05$). In the control group, bite force was negatively correlated with jaw inclination and overbite. There were negative correlations between anterior temporalis thickness and anterior facial dimensions; and positive correlations for masseter and anterior temporalis and posterior dimensions. In the SSTMD group, there were positive correlations for masseter and bite force, and anterior and posterior dimensions. Negative correlations were found for the masseter and temporalis muscles and jaw inclination and vertical jaw relationship. Multiple regression analysis showed that in the control group the overjet and jaw inclination contributed 50 per cent to the variance in bite force. In the SSTMD group, the dimensions of the masseter muscles during contraction contributed 39 per cent to the variance. The correlations between CMI and the craniofacial variables were more significant in the SSTMD group. The findings indicate that muscle thickness influences facial dimensions and bite force in adolescents with SSTMD.

Introduction

The term 'temporomandibular dysfunction' (TMD) refers to signs and symptoms associated with pain, and functional and structural disturbances of the masticatory system, especially the temporomandibular joints (TMJs) and masticatory muscles (Sonnesen *et al.*, 2001).

Ultrasonography has been used to measure masticatory muscle thickness in experimental and clinical studies (Emshoff and Bertram, 1998; Bertram *et al.*, 2001) and confirmed to be a reliable procedure. It can depict the thickness of the masseter and temporalis muscles situated near the surface of the bone structures in the head and neck.

Changes in size and shape of the bony components of the craniofacial skeleton during growth and their influence on the masticatory system have been extensively studied. Many investigators have shown a significant interaction between jaw muscle function and facial morphology (Bakke and Michler, 1991; Raadsheer *et al.*, 1996, 1999; Sonnesen *et al.*, 2001). The potential influence of bite force on the development of masticatory function has also been reported (Braun *et al.*, 1995). Moreover, previous studies have found that low maximal mandibular elevator muscle activity or low bite force are associated with a vertical facial morphology (Raadsheer *et al.*, 1999) and these characteristics are often seen in patients with signs and symptoms (SS) of TMD (Kroon and Naeije, 1992).

Although there have been many studies into the use of ultrasonography for evaluating the masticatory muscles of healthy volunteers (Raadsheer *et al.*, 1996; Kubota *et al.*, 1998) and patients with inflammation (Ariji *et al.*, 2001), this has not been well explored in patients with TMD (Ariji *et al.*, 2004), and especially in young subjects with signs and symptoms.

The aim of the present study was to examine whether any consistent patterns of associations could be found between

SSTMD, craniofacial dimensions, muscle thickness, and bite force in a group of adolescents.

Materials and methods

The Ethics Committee of Piracicaba Dental School approved the research.

The subjects, 12–18 years of age, were selected from public schools in the city of Piracicaba, Brazil. Adolescents who had received any type of orthodontic treatment prior to or during the research period were excluded from the study. Written consent *pro formas* were sent to 600 subjects and the parents, and consent was obtained from 217 subjects (120 girls and 97 boys). Initially, TMD signs were assessed by calculating the craniomandibular index (CMI), as described by Fricton and Schiffman (1986). This was carried out by two calibrated examiners ($\kappa = 0.94$).The CMI has a 0 to 1 scale that measures tenderness and dysfunction in the stomatognathic system and includes all currently recognized signs of TMJ disorders (Fricton and Schiffman, 1986, 1987). There are two subscales: the dysfunction index (DI) and the palpation index (PI). The DI is designed to evaluate limitations in mandibular movement, pain and deviation in movement, TMJ sound, and TMJ tenderness, and the PI the presence of muscle tenderness in the stomatognathic system. Thus, the CMI distinguishes joint problems from muscle problems.

A self-report questionnaire was used to assess the presence of subjective symptoms according to Riolo *et al.* (1987) regarding pain in the jaws when functioning (e.g. chewing), unusually frequent headaches (more than once a week), stiffness/tiredness in the jaws, difficulty in opening the mouth wide, grinding teeth, and sounds in the TMJs. Each question could be answered with 'yes' or 'no'.

Forty adolescents of the 217 subjects were selected to dichotomize the data in order to compare 'extreme' groups. The lower and upper extremity values were used to select the control group (10 boys and 10 girls) and the group with SSTMD (10 boys and 10 girls), respectively. There was a statistically significant difference between group scores for DI, PI, and CMI ($P < 0.05$; Table 1). To be included in the SSTMD group, the subjects had to have at least one symptom of the condition.

Ultrasonography

The masseter and anterior temporalis evaluation was conducted using the Just-Vision 200 digital ultrasonography system (Toshiba Corporation, Otawara, Japan) and the images were obtained with a high-resolution real-time 56mm/10-MHz linear-array transducer. All subjects were examined by one of the authors (LJP) who had no information regarding symptoms or CMI scores. The transducer was positioned against the skin surface over the central portion of the masseter muscle (the area of greatest lateral distention), and for the anterior temporalis it was placed just in front of the anterior border of the hairline. The transducer was moved gradually to obtain optimal visualization. The distance was measured directly on the screen. The measurements were recorded immediately both during relaxation and clenching of the jaws. Scanning was

Table 1 Dysfunction index (DI), palpation index (PI), and craniomandibular index (CMI), muscle thickness in the controls and in the group with signs and symptoms of temporomandibular dysfunction (SSTMD).

					Masseter thickness (mm)				Anterior temporalis thickness (mm)			
		DI	PI	CMI	RR	RC	LR	LC	RR	RC	LR	LC
Control group (n = 20)	Median	0.07	0.00	0.04	10.10	13.35	10.00	12.95	3.05	4.40	3.05	4.55
	(25%)	0.04	0.00	0.02	9.10	12.45	9.48	12.00	2.50	4.10	2.50	3.90
	(75%)	0.07	0.00	0.04	10.80	14.90	10.55	14.00	3.30	4.90	3.35	5.05
	Mean	0.06^{A}	0.01^{A}	0.03^{A}	10.02^{aC}	13.57^{bC}	9.99^{aC}	13.03^{bC}	2.96^{cC}	4.46^{dC}	2.98^{cC}	4.56^{dC}
	SD	0.03	0.02	0.01	1.09	1.30	0.80	1.38	0.56	0.91	0.55	0.72
	SEM	0.01	0.00	0.00	0.24	0.29	0.18	0.31	0.13	0.20	0.12	0.16
SSTMD group (n = 20)	Median	0.14	0.31	0.23	10.50	12.85	10.15	12.65	2.80	4.25	2.85	4.30
	(25%)	0.10	0.22	0.18	9.78	12.00	9.63	11.38	2.60	3.80	2.60	3.95
	(75%)	0.21	0.37	0.24	11.85	14.30	11.55	14.48	3.35	4.80	3.05	4.65
	Mean	0.16^{B}	0.31^{B}	0.23^{B}	10.72^{aC}	13.40^{bC}	10.40^{aC}	13.23^{bC}	2.95^{cC}	4.19^{dC}	2.84^{cC}	4.25^{dC}
	SD	0.10	0.17	0.09	1.62	1.99	1.68	2.20	0.62	0.86	0.34	0.59
	SEM	0.02	0.04	0.02	0.36	0.45	0.38	0.49	0.14	0.19	0.08	0.13

SD, standard deviation; SEM, standard error of the mean; RR, right relaxed; RC, right contracted; LR, left relaxed; LC, left contracted. ^{A,B}Pairs of mean values for the DI, PI, and CMI variables between groups with different capital superscript letters in the same vertical line are significantly different ($P < 0.05$). ^{a,b}(masseter),^{c,d}(anterior temporalis) Pairs of mean values for thickness between the relaxed and contracted muscles with different small superscript letters in the same horizontal line are significantly different ($P < 0.05$). ^{C}Pairs of mean values for thickness between groups with same capital superscript letter in the same vertical line are not significantly different ($P > 0.05$). There were no significant differences between groups for muscle thickness.

performed twice for each site and the means were used for statistical analysis.

Measurement error for ultrasound

The errors of measurement (Se) for the thickness of the masticatory muscles were assessed from repeated measurements on two separate occasions ($m1$, $m2$) of 20 randomly selected subjects (n), using Dahlberg's (1940) formula: $\text{Se} = \sqrt{\sum (m1 - m2)2/2n}$. The error was 0.47 mm for the contracted and 0.26 mm for the relaxed masseter, and 0.32 mm for the contracted and 0.29 mm for the relaxed anterior temporalis.

Craniofacial dimensions

The facial morphology of the subjects was evaluated by one calibrated examiner (LJP) on cephalograms taken with the mandible in the intercuspal position. Facial and dentoalveolar morphology traits were measured directly on profile radiographs. The measurements included anterior (n-gn, n-Me, sp-gn) and posterior (S-tgo) vertical facial dimensions, mandibular inclination (NSL/ML), vertical jaw relationship (NL/ML), gonial angle (ML/RL), and incisor relationships (overbite: ii-io, overjet: is-io). Angular measurements were recorded to the nearest 0.5 degrees and linear measurements to the nearest 0.5 mm without correction for enlargement. The analysed variables are shown in Figure 1.

The measurements, carried out twice, on two different occasions with an interval of at least 2 weeks, showed no significant difference. The method errors of the individual measurements were 1.2 mm and 0.5 degrees, in agreement with Dahlberg's (1940) formula.

Bite force determination

Bite force was determined with a pressurized transducer, which consisted of a pressurized rubber tube connected to a sensor element (MPX 5700, Motorola SPS, Austin, Texas, USA). The tube and the sensor were connected to a converse analogue/digital electronic circuit, fed by an analogue signal from the pressure-sensitive element. The system was connected to a computer for data analysis.

Bite force was measured three times for each subject, during which the subjects occluded on the tube with maximum force three times for 5 seconds, with a 10-second interval between each bite. The tube was placed bilaterally between the posterior maxillary and mandibular first molars. To obtain the highest bite values possible, the adolescents were trained before the test and they were encouraged to do 'their very best'. They were seated in chairs with their heads fixed, keeping the Frankfort plan approximately parallel to the floor. In relation to numeric results, the minimum values were obtained, which corresponded to the initial pressure in the pressurized tube, and the maximum values corresponded to maximum bite force. The difference between maximum and minimum pressures for each evaluation was calculated and the mean value of the three, for each patient, was selected. The values from the pressurized tube were obtained in pounds per square inch (psi) and were converted into Newtons (N), taking into account the area of the tube, since force = pressure × area.

The reliability of the bite force measurements was determined for 10 randomly selected children using Dahlberg's (1940) formula on two repeated measurements. The method error was 6.5 per cent (16.28 N).

Statistical analysis

Multivariate analysis was performed, with the masseter and anterior temporalis muscle thickness as the dependent

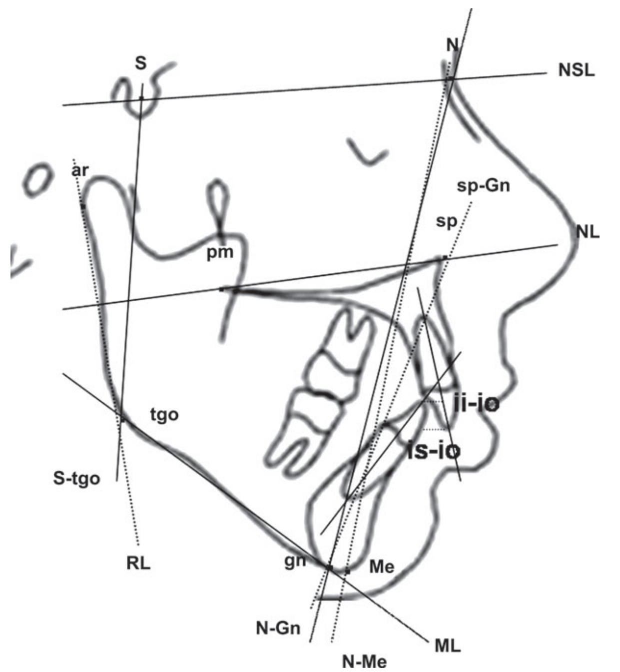

Figure 1 Cephalometric landmarks and abbreviations. Articulare (ar), the point of intersection of the dorsal contour of the condylar head and the contour of the external carnial base; gnathion (Gn), the most inferior point on the mandibular symphysis in the midsagittal plane; gonion-tangent point (tgo), the intersection of the mandibular line (ML) and the ramus line (RL); incision inferius (ii), the midpoint on the incisor edge of the most labially positioned mandibular central incisor; incision superius (is), the midpoint on the incisor edge of the most labially positioned maxillary central incisor; menton (me), the lowest point of the contour of the mandibular symphisis; nasion (N), the anterior limit of the nasofrontal suture; pterygomaxillare (Pm), the intersection of the posterior contour of the maxilla with the contour of the hard palate; sella (S), centre of sella turcica; spina (Sp), the most anterior lying point on the anterior nasal spine, in the midsagittal plane; mandibular plane, the ML tangent to Gnathion and the inferior border of the ramus; palatal plane (NL), the nasal line intersecting anterior and posterior nasal spine; RL, the line tangent to the posterior border of the ramus and the condyle; SN plane (NSL), the nasion-sella line indicates the orientation of anterior cranial base; anterior vertical facial dimension (n-gn, n-Me, sp-gn); posterior vertical facial dimensions (S-tgo); gonial angle (ML/RL); incisor relationship (overbite: ii-io, overjet: is-io); mandibular inclination (NSL/ML); and vertical jaw relationship (NL/ML).

variables, gender as the between-subject factor, and weight and height covariates.

Subsequently, the relationship of bite force magnitude, the craniofacial dimensions and jaw muscles thickness were assessed using Pearson's correlation coefficient and stepwise multiple regression analysis. Multivariate analysis to compare morphological parameters between the groups was employed. As the CMI is a non-parametric scale, the relationship between the craniofacial dimensions and the CMI and subscales was assessed by Spearman's coefficient. Maximum bite force between the groups was compared using a non-paired *t*-test, and muscle thickness between sides and before and after contraction using a paired *t*-test. For all statistical analyses, the Statistical Package for Social Sciences, Version 9.0 (SPSS Inc., Chicago, Illinois, USA) was used.

Results

The descriptive statistics for the CMI and subscales, as well as for masseter and anterior temporalis muscle thickness during relaxation and maximum contraction, are shown in Table 1. The results demonstrated that muscle thickness increased significantly from relaxation to maximum contraction ($P < 0.05$). There was a significant difference between the thickness of the left and right masseter during contraction ($P < 0.05$). Comparison of muscle thickness between the groups was not significant ($P > 0.05$).

The bite force exhibited by subjects in the SSTMD group was smaller than in the control group (302 ± 24 N and 326 ± 40 N, $P < 0.05$, respectively). There were no statistically significant differences in the cephalometric variables between the groups ($P > 0.05$). Multivariate analysis showed that the covariates (weight and height) had a significant influence on the thickness of the masseter and anterior temporalis muscles (weight, $P = 0.010$; height, $P = 0.005$).

The results for the control group (Table 2) demonstrated that bite force was negatively correlated with NSL/ML and overbite. There were significant negative correlations between the thickness of the relaxed temporalis and n-gn, sp-gn, n-Me, as well as for the thickness of the contracted temporalis and n-gn and n-Me. There were positive correlations between a relaxed masseter and n-gn, sp-gn and S-tgo.

For the SSTMD group (Table 3), the results showed that bite force and the thickness of the relaxed and the contracted masseter were significantly correlated with S-tgo. Furthermore, the thickness of the contracted masseter correlated with n-gn and n-Me. Negative correlations were found for the relaxed and contracted masseter muscles and the contracted temporalis muscle with NSL/ML and NL/ML. The relaxed temporalis was negatively correlated with ML/RL.

Multiple regression analysis showed that in the control group, overjet and NSL/ML contributed more than 50 per cent to the variance in bite force. In the SSTMD group, the thickness of the contracted masseters explained 39 per cent of the variance.

For the control group, the cephalometric variable, NSL/ML, was negatively correlated with DI and positively correlated with PI (Spearman's correlation). For the SSTMD group, there was a significant positive correlation between DI and is-io, and negative correlations between PI, n-gn, and n-Me, and between CMI and S-tgo (Table 4).

Discussion

In the present study to evaluate SSTMD, the CMI which uses clearly defined criteria, simple clinical methods, and easy scoring was used. In addition, this index has a good intra- and inter-examiner correlation (Fricton and Schiffman, 1987). Recently, the operational definitions for CMI were redesigned to conform precisely to those of the research diagnostic criteria for temporomandibular disorders (RDC/TMD; Dworkin and LeResche, 1992) resulting in a clinical evaluation protocol—the temporomandibular index (TMI). Ideally, criterion validity should be measured relative to a 'gold standard' (Pehling *et al.*, 2002). As no such standard

Table 2 Pearson's correlation coefficients (*R*) and *P* values for the control group (n = 20).

		MC	TR	n-gn	sp-gn	NSL/ML	ii-io	S-tgo	n-Me
BF	*R*	—	—	—	—	−0.44	−0.61	—	—
	P					0.05*	0.01*		
MR	*R*	0.69	—	0.45	0.45	—	—	0.51	—
	P	0.00*		0.05*	0.05*			0.02*	
MC	*R*	—	—	—	—	—	—	—	—
	P								
TR	*R*	—	—	−0.49	−0.45	—	—	—	−0.55
	P			0.03*	0.05*				0.01*
TC	*R*	—	0.81	−0.48	—	—	—	—	−0.56
	P		0.00*	0.03*					0.01*

BF, bite force; MR, relaxed masseter; MC, contracted masseter; TR, relaxed temporalis; TC, contracted temporalis anterior.
*$P < 0.05$.

Table 3 Pearson's correlation coefficients (*R*) and *P* values for the group with signs and symptoms of temporomandibular dysfunction (SSTMD) (n = 20).

		MR	MC	TR	n-gn	NSL/ML	NL/ML	ML/RL	ii-io	S-tgo	n-Me
BF	*R*	0.45	0.63	—	—	—	—	—	—	0.45	—
	P	0.05*	0.00*							0.05*	
MR	*R*	—	0.86	—	—	−0.74	−0.50	—	−0.51	0.80	—
	P		0.00*			0.00*	0.03*		0.02*	0.00*	
MC	*R*	—	—	—	0.05	−0.58	−0.49	—	—	0.79	0.48
	P				0.03*	0.01*	0.03*			0.00*	0.03*
TR	*R*	—	—	—	—	—	—	−0.54	—	—	—
	P							0.02*			
TC	*R*	—	—	0.72	—	−0.49	−0.47	—	—	—	—
	P			0.00*		0.03*	0.04*				

BF, bite force; MR, relaxed masseter; MC, contracted masseter; TR, relaxed temporalis; TC, contracted temporalis anterior.
*$P < 0.05$.

Table 4 Spearman correlation coefficient (*R*) and *P* values for the control and the group with signs and symptoms of temporomandibular dysfunction (SSTMD).

		SSTMD group (n = 20)				Control group (n = 20)
		n-gn	is-io	S-tgo	n-Me	NSL/ML
Dysfunction index	*R*	—	0.63	—	—	−0.45
	P		0.00*			0.05*
Palpation index	*R*	−0.54	—	—	−0.54	0.56
	P	0.01*			0.02*	0.01*
Cranio-mandibular index	*R*	—	—	−0.45	—	—
	P			0.05*		

*$P < 0.05$.

exists for TMD, criterion validity of a new index requires it to be compared with an accepted index that measures the same condition. Since the CMI has been used and validated repeatedly in clinical studies, the TMI was compared with it. Criterion validity of the TMI and CMI has shown excellent agreement (0.97; Pehling *et al.*, 2002). Because the CMI/TMI instruments include almost the same examination items as the RDC/TMD, the diagnostic outcomes would be expected to be similar to those of RDC/TMD (Pehling *et al.*, 2002). To avoid using subjective and descriptive reports in the assessment of the severity of TMD, CMI is recommended as the clinical criteria (Fu *et al.*, 2002).

In the present study, bite force was significantly lower in the SSTMD group when compared with the matched controls. According to Ahlberg *et al.* (2003), TMJ dysfunction has a significant negative association with molar bite force. A high score on Helkimo's clinical dysfunction index (Helkimo, 1974) related to muscle tenderness and a 'long face' type of craniofacial morphology was also associated with smaller values for bite force (Sonnesen *et al.*, 2001). The results of the present study support the hypothesis that maximum bite force could be reduced by pain in jaw-closing muscles or in the TMJ (Bonjardim *et al.*, 2005).

This research showed that muscle area increased significantly between relaxation and maximum contraction, supporting the findings of Bakke *et al.* (1992). The subjects were asked to achieve maximum muscle contraction in the intercuspal position, which was chosen because any other position might have influenced the vertical dimensions of the masseter, and thus the muscle thickness by stretching. However, since premature occlusal contacts were not taken into account, it is possible that this position does not always coincide with maximum muscle activation bilaterally and therefore, in some subjects, the muscle thickness measurements might not be indicative of the true muscle contraction potential. This could have been one reason for the difference in muscle thickness found between the right and left side for the contracted masseter in the control group.

The number of occlusal contacts affects muscle activity and a reduction in the number of occlusal contacts might result in insufficient development of masticatory muscle strength (van Spronsen *et al.*, 1996). Nevertheless, humans are not perfectly symmetric, which could also explain the variation in absolute muscle size. The mean muscle thickness values found for both groups (Table 1) are in agreement with the literature (Kiliaridis and Kalebo, 1991; Bakke *et al.*, 1992; Ruf *et al.*, 1994; Raadsheer *et al.*, 1999). There was no difference in muscle thickness between the two groups, probably due to the age of sample and the SSTMD, which, even when present, tended to be mild to moderate, and might not be sufficient to cause an alteration in muscle size.

Multivariate analysis showed that the covariates, weight and height, influenced muscle thickness. The relationship between height and weight on the one hand and muscle thickness on the other, in subjects with SSTMD is still not well understood. According to Kiliaridis and Kalebo (1991) and Raadsheer *et al.* (1996, 1999), body variables also influence muscle thickness. The influence of body variables is in agreement with the hypothesis that there is an increase in body mass and stature at puberty, leading to a proportional increase in muscle thickness.

There were negative correlations in the control group between bite force and jaw inclination (NSL/ML), and overbite. A previous study has found that a low bite force has a negative association with mandibular inclination (Raadsheer *et al.*, 1999). In the SSTMD group, there was a significant positive correlation between bite force and masseter thickness. According to Raadsheer *et al.* (1999), the only muscle that showed a significant relation to bite force was the masseter. In the present research, in both groups, there were significant correlations between craniofacial morphology and masseter and anterior temporalis muscle thickness. There was a weak positive correlation between the thickness of the masseter muscle and anterior facial dimensions (n-gn, n-Me, sp-g). However, there were stronger correlations for posterior facial dimension (S-tgo), and negative correlations for mandibular inclination (NSL/ML and NL/ML), indicating that short-faced individuals would appear to have a stronger masseters (Raadsheer *et al.*, 1999). Farella *et al.* (2003) stated that the masseter muscle was significantly thicker (+15 per cent) in short-faced than in normal and long-faced subjects. The anterior temporalis muscle was negatively associated with anterior facial dimensions in the control group, and with gonial angle in the SSTMD group. These results suggest that long-faced subjects have thinner anterior temporalis muscles. van Spronsen *et al.* (1991) also found a relationship between the cross-sectional area of the temporalis muscle and facial morphology. A significant negative correlation was found between the flexure of the cranial base and the temporalis muscle cross-section.

Multiple regression analysis of the data in this investigation showed that overjet and mandibular inclination (50 per cent) in the control group and masseter thickness (39 per cent) in the SSTMD group were the most important factors explaining the difference in bite force. These results are in agreement with Raadsheer *et al.* (1999), who also found that masseter thickness was the main contributor to the variance in bite force magnitude. Masseter thickness did not influence bite force in the control group, which can be explained by the lower standard deviation for this variable in the present sample. This indicates that the range of muscle thickness was smaller in the control group than in the SSTMD group.

The correlations between craniofacial dimensions and SSTMD showed that mandibular inclination was negatively associated with the DI and more strongly positively correlated with PI in the control group. These results are in agreement with Sonnesen *et al.* (2001), who suggested that muscle tenderness occurs in subjects with morphological traits that are consistent with a long face craniofacial morphology. Surprisingly, in the SSTMD group, there were negative correlations for PI and anterior facial dimensions (n-gn and n-Me). As most of the adolescents in this group had short faces, this might be an explanation for the findings. This was based on the anterior to posterior ratio and also the fact that the posterior dimension (S-tgo) was negatively correlated with CMI in this group. The overjet was positively correlated with DI, which is in agreement with Pahkala and Qvarnström (2004) who found that an excessive overjet was the only variable that consistently appeared to increase the risk of TMD.

Conclusions

The present findings support the concept that subjects with different craniofacial morphologies have differences in their masticatory muscles. However, it would not appear to be possible to draw any firm conclusions about the presence of any particular morphology in adolescents with signs or symptoms of TMJ dysfunction, since there was no difference in the morphological parameters between groups ($P > 0.05$). In general, TMD signs and symptoms were seen in connection with an increasing overjet and long-face characteristics, but no particular trait can be considered predictive of dysfunction. On the other hand, the associations provide an insight into possible aetiological factors, and may therefore be of importance for a better understanding of the occurrence of SSTMD.

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