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Cover Page Footnote

This study was supported by a grant from the Polish Ministry of Education (project no. N N403 589138) and was approved by the Ethical Committee of Jagiellonian University (KBET//89B/2009). We would like to express our appreciation to Bio-Research (Milwaukee, WI, USA) for their training on the BioEMG and T-scan III systems and help with BIO-FLEX sensors, and to Tekscan, Inc. (South Boston, Ma, USA) for the donation of sensors.

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ORIGINAL ARTICLE

Associations of Electromyographic Activity of Anterior Temporalis Muscles, Sex, and Occlusal Classes in Asymptomatic Young Adults

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ABSTRACT

Symmetry evaluation of the craniofacial complex generally involves models of mandibular movement and masticatory muscle activity, especially during the growth of the craniofacial complex. **Objectives:** The aim of the study was to determine what, if any, associations exist between the activity of the masticatory muscles, sex, and occlusal classes in asymptomatic young adults. **Methods:**18-year-old volunteers, showing no symptoms of TMD based on an RDC/TMD examination, were included in the study.Surface electromyography (sEMG) recording was used to quantify the activity of masticatory muscles. The occlusal contact points were analyzed using a T-scan III Evolution 7.01 device. Occlusal classes were graded, employing an approach based on plaster study models. **Results:** In Class I–II subjects, we found significant differences only in the voltage of LTA in correlation with the gender and occlusal Class. **Conclusions:** Our findings show that the electromyography voltage of LTA significantly differs according to sex and occlusal Class. The voltage is higher in the female occlusal class II group, while the voltage is less in the male Class I and II group. This may be responsible for the symmetry index, which shows the predominance of the right-side muscles in all gender and occlusal groups.

Key words: electromyography, young adult, anterior temporal muscles

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INTRODUCTION

During the development of the craniofacial complex, multidirectional forces of the mastication muscles act on the teeth undergoing eruption. The place in which the tooth erupts depending on where opposing forces are in equilibrium. Interarch tooth alignment, which during the closing of the mandible, determines occlusal contact of the teeth, determines its quality. The contact between the opposing teeth generates reflex stimuli causing muscles to contract.[1] The distribution of the intercuspal contact between opposing teeth may be related to the spread of electrical voltage of paired masticatory muscles during contraction. This symmetry can be investigated with electromyography (EMG). It is indeed difficult to directly examine tension using elementary EMG of the muscles during movement.[2] During the examination, it is necessary to place the unipolar needle electrodes inside the muscles. Surface EMG, is vulnerable to extramuscular factors that can interfere with electrical signals of exact muscular origin, whereas the results obtained with well-standardized protocols closely reflect intramuscular recordings.[3]

A T-scan device allows the percentage distribution of occlusal contact (occlusal force) to be recorded. To the best of our knowledge, the relationships between masticatory muscle activity at maximal occlusal contact by gender have not been reported so far. Using these two methods, and by additionally considering the occlusal classes, we sought a relationship between the asymmetry of the masticatory muscles and occlusal classes in a homogenous group of asymptomatic 18-year-old young adults. Additionally, in the foregoing study was included relatively small number of patients and the groups were not homogeneous in age; they were examined when differences in muscular activity were associated with occlusal trauma.

In Ferrario's study, electromyography activity was measured in 92 subjects (49 male and 43 female), 20–27 years old, and selected from 160 Caucasian

dental students with the absence of moderate and severe clinical mandibular disorders.[4] They were not divided into the occlusal class group, and they may have had minor clinical mandibular disorders. In another study, Ferrario analyzed 30 participants (15 women and 15 men) aged 18–19 years of occlusal Class I only.[3] We focused the analysis on subjects aged 18 years when craniofacial development has virtually terminated, and possible pathological influences can be considered minimal.

OBJECTIVE

Our aim was to validate the hypothesis that there exist associations between the activity of the masticatory muscles—namely, the left temporalis anterior (LTA), the right temporalis anterior (RTA), the left masseter muscles (LMM), and the right masseter muscles (RMM)—gender, and I, II, III Angle'a Classes in non-patients young adults.

METHODS

We invited Caucasian school seniors aged 18 years from two high schools. In the screening phase, 268 out of the 1000 invited subjects who were willing to participate in the project underwent clinical examination. They were examined and completed the RDC/TMD - temporomandibular disorder questionnaire in polish version. [5-8] All the volunteers had signed informed consent forms. The research was conducted following the *Declaration of Helsinki ICH Guidelines for Good Clinical Practice*. The research study had been approved by the Ethical Committee of Jagiellonian University. The inclusion criteria were: a full dental arch, no symptoms of TMD according to RDC/TMD the symmetry of facial structures. The exclusion criteria were tooth decay, periodontitis, any fixed or removable denture, parafunction and any pathology in craniofacial structures.

Finally, 145 subjects underwent the study. To the study, we chose surface electromyography (sEMG) an 8-channel BioEMG III BioPAK Measurement System Electromyograph (BioResearch, Inc., Milwaukee, WI, USA) and to examine the occlusal contact points between tooth was used T-scan III evolution 7.01 device (Tekscan Inc., South Boston, MA, USA). The T-scan III / BioEMG has a synchronization module that allows for the simultaneous acquisition of occlusal function and associated muscle activity, which were examined.[9]

All examinations were performed in the morning. At first, the volunteers were seated isolated in the exanimation room in a quiet environment listening to relaxing music. At first, the skin was cleaned with alcohol, the bipolar surface electrodes (Bio FLEX, BioResearch Associates, Inc., Brown Deer, WI, USA) were placed bilaterally on the subject's skin overlying the anterior temporalis - vertically along the anterior muscular margin. Electrodes for the masseter muscles were placed parallel to the muscle fibers.[10] A plate ground electrode was secured to the forehead. The sensor of the T-scan was placed in the mouth. During the examination, they seated upright on a chair, and the volunteer was asked to close their jaws as hard as possible. When a force of occlusal contact is exerted on the sensor, the simultaneous record of the distribution of occlusal contacts and voltage of the examined muscle is started. The record is displayed for clinical analysis.[10,11-13] They were asked to hold their teeth hard together for 3 seconds and then open.[14] All registrations were repeated two more times. All details of this protocol are described in an article by Wieczorek et al.[9,15]

When the point 100% of possible contact was reached, this same point was selected from the voltage of the anterior temporalis muscle (TA) and the masseter muscle (MM). This was possible thanks T-scan III / BioEMG III integration software, which is showing the voltage of the muscles at any moment of occlusal contacts was reached.

As described previously, measurement variability was assessed by repeated sEMG analysis.[9] Accuracy and precision were represented by the intraclass correlation coefficient (ICC). To describe the asymmetry of the masticatory muscles, an asymmetry index was calculated using the following formula based on the root mean square (RMS). Asymmetry index (AsI) = $(RMS_{right} - RMS_{left})/(RMS_{right} + RMS_{left}) \times 100$

The value of AsI can vary from + 100 to -100, with an AsI of +100 or -100 being equivalent to an absolute predominance of right-side (R) or left-side (L) muscle activity, respectively, whereas a perfectly balanced activity of R/L muscles is represented by an AsI of zero. AsI was proposed by Naeije et al.[16]

The subjects were classified into three occlusal classes using plaster study models taken during examination by alginate impressions of the maxillae and mandibles of the volunteers.

Statistical analysis

All data were analyzed using the SPSS (Statistical Package for Social Sciences) Statistics 17.0 (2008) for Windows. Agreement with a normal distribution was tested using the Kolmogorov–Smirnov test (with Lillefors' correction) and the Shapiro–Wilk test. For normally distributed variables, the differences between 3 occlusal classes were tested by one-way ANOVA followed by post-hoc Tukey's HSD test for unequal *n*.

Differences between sex were assessed by Student's *t*-test or the Mann–Whitney *U* test. The Intraclass Correlation Coefficient (ICC) was quantified with the *F*-test. A p-value below 0.05 was taken as significant.

RESULTS

The ICC of measurement variability was calculated to be 0.765. The entire group of 145 volunteers was divided according to occlusal Class, based on analysis of the plaster models created during the examination. Ninety-seven (97) volunteers were classified as occlusal Class I, 36 as Class II, and the remaining 12 subjects presented Class III features. No significant interclass differences in right-side and left-side activity of the MM or TA were found (Table 1). We next excluded from the study those samples with occlusal Class III, because of the number of participants involved.

In the next step, analysis of the voltage of all muscles according to sex and occlusal Class was performed. The only significant finding was an association between LTA voltage and sex and occlusal Class ($p = 0.02$). Additionally, we observed a lower LTA voltage in men and a higher LTA voltage in women of occlusal Class II (Figure.1)

To determine if this lower voltage influences the balance of masticatory muscles, calculation of the AsI, which showed the predominance of the right-side muscles was done. This tendency towards balance was shown only in occlusal Class II in the female group. (Figure. 2)

Table 1. Activity of left temporalis anterior muscle (LTA), right temporalis anterior muscle (RTA), left masseter muscle (LMM), right masseter muscle (RMM), according to occlusal Class.

	Occlusal class	N	Mean	SD	p-value *
RTA (μV)	Class I	97	126.63	77.08	0.85
	Class II	36	123.92	67.42	
LTA (μV)	Class I	97	96.79	46.30	0.19
	Class II	36	108.62	60.60	
RMM (μV)	Class I	97	124.32	76.35	0.47
	Class II	36	135.00	77.49	
LMM (μV)	Class I	97	118.92	83.87	0.44
	Class II	36	130.84	71.41	

*ANOVA, p-value<0.05

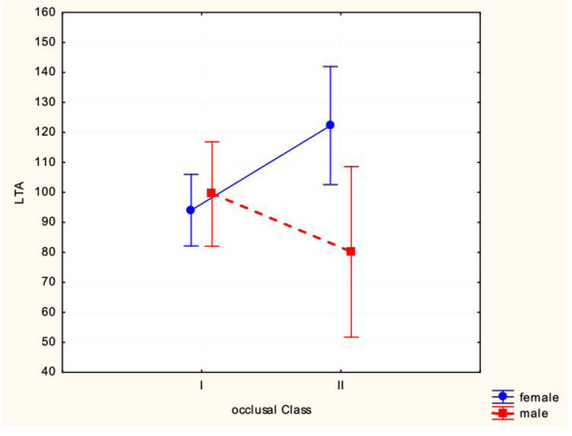

Figure 1. Association between voltage of LTA (left anterior temporalis muscle) and gender and occlusal Class. (ANOVA, p-value =0.02)

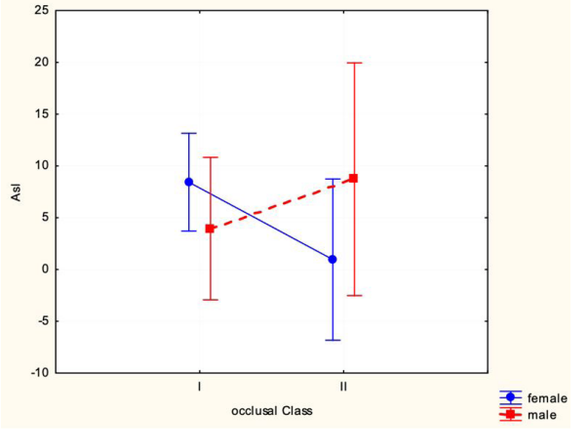

Figure 2. Association between AsI (Asymmetry index), gender and occlusal Class. (ANOVA, p=0.13)

DISCUSSION

Our findings show that the electromyography voltage of the LTA significantly differs from gender and occlusal Class. The voltage is higher in the female occlusal class II group, while the voltage decreases from the male Class I to class II group. The symmetry index (AsI) shows the predominance of the right-side muscles in all gender and occlusal groups.

We analyzed EMG data recorded at 100% occlusal contact by examining young adult volunteers lacking signs of temporomandibular disorders (according to the RDC/TMD). The age group was chosen to guarantee that the development of the stomatognathic system would have finished and that wear on the masticatory organs would be minimal. Analyzing the asymmetry index, we observed the predominance of the right-side muscles in all occlusal classes. The differences in the asymmetric index were not significant across occlusal Classes.

One interesting finding occurred as a result of dividing occlusal Class groups by gender. Significant differences were observed between gender groups and occlusal classes in the LTA voltage. These differences probably directly influenced differences in the asymmetry index, which show the predominance of the right-side muscles in the subjects of classes I and II. The dominance of right-side muscles was observed in the study by Ferrario et al. [3], but the participants were selected from 20–27 years old dental students. They were not divided by occlusal Class. Additionally, there were no significant differences in the gender groups between the electrical potentials of LTA or RTA—only between LMM and RMM.

A literature search on the relationship between the distribution of occlusal contacts and EMG of the masseter and anterior temporal muscles did not reveal many studies involving a comparable age group. The studies we did find aimed at understanding the influence of artificial interference on the voltage of the temporalis anterior and masseter muscles [14] or psychological status.[17] Some researchers have examined the asymmetry between the left and right muscles during clenching.[3] Suvinen et al.[18] have reported that, even in the mandibular postural position, asymptomatic muscles are physiologically asymmetrical and that asymmetry and activity indices of 4% and 17%, respectively, should be considered normal. In analyzing sex and occlusal Class, we found that the only muscle that differed was the LTA.

Ferrario et al. showed that healthy individuals have a prevalent side on which they generate higher muscular activity levels during bilateral clenching.[4] However, this should affect the activity of the masseter muscles, and we did not find any association between sex and occlusal class group for these muscles. However, in these two groups, it was also found that the predominance of intensity was on the right side. Additionally, in our previous study, we found significant differences in RTA voltage between sexes, with the male group showing a significantly lower the voltage than the female group.[15] Based on our results, it may be concluded that, in asymptomatic patients, asymmetry of electromyography potential of mastication muscles tends to affect the right side. It could also be interesting to determine whether the mandible structure affects the electromyography voltage of the LTA and the asymmetry of the masticatory muscles. Lower LTA voltages do affect the ideal balance of the masticatory muscles, and the asymmetry index shows the predominance of the right-side muscles.

The T-scan III can be integrated with the BioEmg III system. In this way, synchronized clinical data can be recorded simultaneously.[13] At present, the T-scan III/ BioEMG integration software is considered the best tool on the market. It allows simultaneous recording and analysis of the sEMG of selected muscles and the distribution of occlusal force while correlating specific occlusal moments with specific electromyographic changes.

CONCLUSION

Our findings show that the electromyography voltage of the LTA differs significantly by sex and occlusal Class, with the voltage being higher in the female occlusal class II group, and decreasing from occlusal Class I to II the make group. This may be responsible for the symmetry index, which, in all gender and occlusal groups, shows the predominance of the right-side muscles.

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CONFLICT OF INTERESTS

The authors declare no potential conflicts of interest concerning the authorship or publication of this article.

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