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Sex differences in masticatory muscle activity in healthy young adults

Abstract

Introduction. Several studies analyzed the gender differences in masticatory muscle activity. Previous scientific reports indicate the predominance of the masseter muscle activity in male subjects and the predominance of the temporalis anterior in women. However, there is a lack of studies analyzing the differences in the activity of the mandibular abduction muscles between men and women.

Aim. The presented study evaluated the sex differences in activity within temporalis anterior, masseter, and digastric muscle in healthy young adults.

Material and methods. Thirty-six healthy young adults aged 20 to 29 years (mean 22±2.6 years) were qualified for the presented study. The subjects were divided into two equal groups (n=18) in terms of gender. The masticatory muscle activity was recorded within the temporalis anterior (TA), the superficial masseter muscle (MM), and the anterior bellies of the digastric muscle (DA). Electromyographic activity was recorded in three conditions: at rest, during maximum voluntary clenching at the intercuspal position, and during maximum voluntary clenching with cotton rolls between teeth.

Results. Significant differences in electromyographic activity between the male and female group were observed within resting activity for the TA-R (Women: 1.98 μV vs. Men: 1.26 μV; p=0.000), TA-L (Women: 2.13 μV vs. Men: 1.33 μV; p=0.000), DA-R (Women: 2.17 μV vs. Men: 1.29 μV; p=0.001), DA-L (Women: 2.13 μV vs. Men: 1.37 μV; p=0.005). Moreover, significant difference in resting activity index was observed within left side (Women: -9.89 % vs. Men: 10.39%; p=0.037), and within right side during clenching with cotton rolls between teeth (Women: 9.83% vs. Men: 25.59%; p=0.016).

Conclusions. Women represent higher resting sEMG activity within the temporalis anterior and digastric muscles than men. Electromyographic patterns may be influenced by gender at rest and during clenching tasks.

Keywords: sEMG, masticatory muscles, sex, young adults.

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INTRODUCTION

The anatomical structure of the craniofacial and stomatognathic systems has a significant impact on the biomechanics within the masticatory system. Sex differences within these systems have been demonstrated in numerous studies. The female population showed a more prominent frontal bone and a less prominent nasal bone than males [1]. Moreover, men had significantly greater intercochlear distance, mean osseous auditory tube length, mastoid length, sella to basion distance, and nasopharynx sagittal area [2]. In addition, the Sella–Nasion Subspinale Angle (SNA) is larger in their male subjects by 2.0° [3]. The contact area, the arch length/width, and the bite force are significantly larger in men than in women. The larger arch size may be related to larger tooth size in the male population [4]. The difference in body size between males and females is also a key factor associated with masticatory performance [5].

Several studies analyzed the gender differences in masticatory muscle activity [6,7]. The above mentioned studies indicate the predominance of the masseter muscle activity in male subjects and the predominance of the temporalis anterior in women. Both studies concerned healthy people without functional disorders within the masticatory system, e.g., temporomandibular disorders (TMDs), and included only the electromyographic activity of the masseter and temporalis anterior muscles. Hence, the above results only apply to the agonist muscles responsible for clenching the teeth. However, there is a lack of studies analyzing the differences in the activity of the mandibular abduction muscles between men and women.

AIM

The presented study aimed to evaluate the sex differences in activity within the temporalis anterior, the superficial masseter muscle, and anterior bellies of the digastric muscle in healthy young adults. The null hypothesis is that there will be differences

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in the activity of the masticatory muscles between men and women at rest and during clenching tasks.

MATERIAL AND METHODS

The presented study was carried out at the Independent Unit of Functional Masticatory Disorders, Medical University of Lublin, by experienced dentists and physiotherapists. The measurements were carried out according to the Helsinki Declaration's recommendations and with the Bioethics Committee's consent of the Medical University of Lublin (KE-0254/346/2016). All participants were informed about the aim of the study and have given written permission for the research.

The inclusion criteria used in the presented experiment were: age range 18–30 years, and good/very good health status based on the RDC/TMD questionnaire. The following exclusion criteria were used: head and neck injuries within the last six months before the study, the occurrence of headache and cervical spine pain, previous head and neck surgery, II and III class according to Angle's classification, open bite, lack of four support zones in dental arches, carious or damaged dental tissues, periodontal pathology, any form of TMDs found according to the RDC/TMD measurement; orthodontic treatment; possession of dental prostheses, pregnancy. After applying the inclusion/exclusion criteria, 36 healthy young adults aged from 20 to 29 years (mean 22±2.6 years) qualified for the presented study. The subjects were divided into two equal groups (n=18) in terms of gender.

Electromyographic measurement was carried out in a dental chair in a sitting position, with the body perpendicular to the ground, the head resting on the chair's headrest, and the lower limbs upright and arranged parallel. The masticatory muscle activity was recorded using an 8-channel device BioEMG II-ITM (BioResearch Associates, Inc., Milwaukee, WI, USA). First, the skin was cleaned with 90% ethanol solution to reduce skin impedance. Next, surface electrodes (Ag/AgCl, diameter 30 mm, the conductive surface of 16 mm, SORIMEX, Toruń, Poland) were placed following the course of the muscle fibers of the temporalis anterior (TA), the superficial masseter muscle (MM), and anterior bellies of the digastric muscle (DA). The reference electrode was placed on the forehead. Electromyographic activity was recorded in three conditions: at rest (10 seconds), during maximum voluntary clenching at the intercuspal position (3×3 seconds, 2 seconds rest between clenching), and during maximum voluntary clenching with cotton rolls between teeth (3×3 seconds, 2 seconds rest between clenching). The post-processing of the sEMG raw signal by the RMS calculation in the BioPAK Measurement System program gave average measurement values. The following calculations were used for the assessment of activity (AcI) and asymmetry (AsI) indices from the average RMS potentials, according to Naeije et al. and Ferrario et al. [6,8]

Asymmetry index for temporalis (AsI TA) = (TA-R − TA-L) /(TA-R + TA-L) × 100%

Asymmetry index for masseter (AsI MM) = (MM-R − MM-L) /(MM-R + MM-L) × 100%

Asymmetry index for digastric (AsI DA) = (DA-R − DA-L) /(DA-R + DA-L) × 100%

Activity index for right side (AcI-R) = (MM-R − TA-R) /(MM-R + TA-R) × 100%

Activity index for left side (AcI-L) = (MM-L − TA-L) /(MM-L + TA-L) × 100%

The data comparison was performed using the IBM SPSS STATISTICS 21 program. The Shapiro-Wilk test and the Kolmogorov-Smirnov test (with the Lillierfors correction) revealed the data are not distributed normally, therefore the nonparametric Mann-Whitney U test was used. The differences were considered statistically significant if the level of test probability was lower than the assumed level of significance ($p<0.05$).

RESULTS

Statistical analysis showed no significant difference between the male and female groups regarding age (p=0.145), as presented in Table 1.

TABLE 1. The comparison of the average age between women and men.

	Women (n=18)		Men (n=18)		Z	p
	M	SD	M	SD		
Age (years)	22.17	1.95	23.61	2,95	-1.459	0.145

Significant differences in electromyographic activity between the male and female group were observed within resting activity for the TA-R (Women: 1.98 μV vs. Men: 1.26 μV; p=0.000), TA-L (Women: 2.13 μV vs. Men: 1.33 μV; p=0.000), DA-R (Women: 2.17 μV vs. Men: 1.29 μV; p=0.001), DA-L (Women: 2.13 μV vs. Men: 1.37 μV; p=0.005). Moreover, significant difference in activity index between the male and female group was observed within left side (Women: -9.89% vs. Men: 10.39%; p=0.037), as presented in Table 2.

TABLE 2. The comparison of average resting masticatory muscle activity between women and men.

	Women (n=18)		Men (n=18)		Z	p
	M	SD	M	SD		
TA-R	1.98 μV	0.54 μV	1.26 μV	0.32 μV	-4.272	0.000*
TA-L	2.13 μV	0.56 μV	1.33 μV	0.32 μV	-4.556	0.000*
MM-R	1.61 μV	0.37 μV	1.77 μV	1.23 μV	-0.791	0.429
MM-L	1.86 μV	0.95 μV	1.92 μV	1.31 μV	-0.269	0.788
DA-R	2.17 μV	1.25 μV	1.29 μV	0.46 μV	-3.370	0.001*
DA-L	2.13 μV	0.98 μV	1.37 μV	0.55 μV	-2.832	0.005*
AsI TA	-3.51%	11.76%	-2.42 %	12.36%	-0.032	0.975
AsI MM	-3.25%	15.40%	-4.47 %	21.04%	-0.475	0.635
AsI DA	0.34%	13.31%	-2.83 %	12.50%	-0.569	0.569
AcI-R	-9.70%	16.70%	7.91%	29.28%	-1.772	0.076
AcI-L	-9.89%	25.15%	10.39%	26.30%	-2.088	0.037*

There were no significant differences between the male and female groups within all analyzed variables during maximum voluntary clenching in intercuspal position (Table 3).

TABLE 3. The comparison of average masticatory muscle activity between women and men during maximum voluntary clenching in intercuspal position.

	Women (n=18)		Men (n=18)		Z	p
	M	SD	M	SD		
TA-R	127.08 μV	81.68 μV	98.29 μV	36.90 μV	-1.107	0.268
TA-L	140.87 μV	88.41 μV	103.91 μV	40.15 μV	-1.582	0.114
MM-R	126.74 μV	122.66 μV	139.98 μV	91.78 μV	-0.918	0.359
MM-L	134.49 μV	104.04 μV	139.96 μV	84.85 μV	-0.649	0.517
DA-R	24.63 μV	19.63 μV	18.69 μV	16.24 μV	-1.646	0.100
DA-L	21.63 μV	13.61 μV	21.98 μV	30.86 μV	-1.313	0.189
AsI TA	-7.39%	12.99%	-2.09%	16.38%	-1.076	0.282
AsI MM	-9.22%	24.22%	1.13%	16.21%	-1.360	0.174
AsI DA	3.24%	11.40%	-1.73%	18.91%	-1.202	0.229
AcI-R	-4.95%	31.32%	9.89%	26.02%	-1.392	0.164
AcI-L	-2.81%	31.82%	7.13%	28.03%	-1.234	0.217

Statistical analysis showed a significant difference between the male and female groups regarding activity index for the right side during maximum voluntary clenching with cotton rolls between teeth (Women: 9.83% vs. Men: 25.59%; p=0.016), as presented in Table 4.

TABLE 4. The comparison of average masticatory muscle activity between women and men during maximum voluntary clenching with cotton rolls between teeth.

	Women (n=18)		Men (n=18)		Z	p
	M	SD	M	SD		
TA-R	121.53 μV	70.80 μV	119.47 μV	49.00 μV	-0.190	0.849
TA-L	135.42 μV	88.25 μV	130.12 μV	53.47 μV	-0.032	0.975
MM-R	149.29 μV	100.34 μV	214.62 μV	117.65 μV	-1.962	0.050
MM-L	163.38 μV	110.20 μV	211.02 μV	106.13 μV	-1.803	0.071
DA-R	28.65 μV	19.07 μV	24.94 μV	19.07 μV	-0.728	0.467
DA-L	22.99 μV	10.63 μV	22.69 μV	16.41 μV	-0.775	0.438
AsI TA	-4.16%	15.24%	-2.15%	17.17%	-0.538	0.591
AsI MM	-6.17%	17.54%	0.51%	16.52%	-0.981	0.327
AsI DA	7.67%	18.20%	4.99%	20.65%	-0.411	0.681
AcI-R	9.83%	16.75%	25.59%	18.85%	-2.405	0.016*
AcI-L	11.28%	27.00%	23.10%	19.69%	-1.329	0.184

DISCUSSION

Differences in electromyographic patterns within masticatory muscles may result from the clenching force generation between subjects, e.g., athletes vs. physically inactive people [9] or craniofacial morphologies, e.g., long-face subjects vs. subjects with normal facial dimensions [10]. On the other hand, the increased or decreased electromyographic activity and asymmetry between the right and left sides of masticatory muscles may suggest functional disorders within the stomatognathic system. Differences in the activity and asymmetry of masticatory muscle activity may occur in the case of masticatory muscle pain [11], occlusion contact area asymmetry [12], or reorganization of masticatory muscle activity in patients with chronic temporomandibular disorders [15]. Significant changes in the masticatory muscle activity were also observed in patients during orthodontic treatment [7], with tension-type headaches [13] and bruxism [14]. Electromyographic differences within masticatory muscles may also be related to gender. However, only a few studies have considered this phenomenon, pointing to the need for more extensive research in this field [6,7]. Moreover, there is a lack of studies analyzing the differences in the activity of the mandibular abduction muscles between men and women. Therefore, the presented study aimed to evaluate the sex differences in activity within temporalis anterior, the superficial masseter muscle, and anterior bellies of the digastric muscle in healthy young adults.

We observed significant differences in electromyographic activity between the male and female group within resting activity for the temporalis anterior and digastric muscle. More precisely, women represented significantly higher electromyographic values than men. A study by Bigaton et al. demonstrates predomination of temporalis anterior in women at rest, which seems to be in line with our results [15]. Moreover, Ferrario et al.'s study indicates that temporalis anterior muscle activity in the female population tended to dominate at every contraction level. In contrast, masseter activity was higher in male subjects during clenching [6]. Although the electromyographic values during clenching did not reach the assumed level of significance, we also observed a tendency for higher activity of the masseter muscles in men. Moreover, we observed a significant difference in activity index between the male and female groups at rest and during maximum voluntary clenching with cotton rolls between teeth. More specifically, the AcI values suggest temporalis anterior advantage at rest and during clenching tasks in women. Our results seem to be in line with the Wieczorek and Loster's study [7]. They showed a predominance of the temporalis anterior muscle in females and the advantage of the masseter muscle in males during clenching activity.

The temporalis anterior and digastric muscle activity changes seem to be related to a higher muscle activation strategy to maintain homeostasis. On the other hand, differences in the bioelectrical activity of the above-mentioned muscles between healthy men and women may result from morphological differences in the craniofacial area, masticatory forces, and physiological parameters. Moreover, results of the electromyographic examination should be evaluated with caution when there is no gender matching of the participants within the study groups.

CONCLUSIONS

Women represent higher resting sEMG activity within the temporalis anterior and digastric muscles than men. Electromyographic patterns may be influenced by gender at rest and during clenching tasks.

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