Original Article

Electromyographic Activity of Masseter and Temporal Muscles with Different Facial Types

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ABSTRACT

Objectives: To compare the electromyographic (EMG) activity of the masseter and anterior portion of temporal muscles in different vertical facial types.

Materials and Methods: Clinical examination, cephalometric analysis, and electromyographic examination were performed in 44 volunteers ranging from 18 to 35 years old. The volunteers were classified on the basis of their vertical facial characteristics into three groups—brachyfacial, mesofacial, and dolicofacial—by the grouping analysis. The EMG records were obtained with three repetitions during mandibular rest, maximum voluntary contraction in intercuspidation, and simultaneous bilateral isotonic contraction. The Kolmogorov-Smirnov and Levene tests were applied to verify the normality and homogeneity of variance. Analysis of variance and the Kruskal-Wallis test identified statistical differences among groups that did not present normality and homogeneity of distribution, respectively. Significance for all statistical tests was set at $P < .05$.

Results: At rest, only the right temporal and masseter muscles presented statistically significant differences among the groups. The differences were observed between groups 1 and 2 ($P = .02$) and 1 and 3 ($P = .038$) for the right temporal muscle, and between groups 1 and 2 ($P = .029$) for the right masseter muscle. Generally, group 1 presented the lowest EMG values for the four muscles evaluated during rest. For isotonic evaluation, none of the groups of muscles presented statistically significant differences.

Conclusion: Different vertical facial types do not determine distinct patterns of EMG activity for the masseter and anterior portion of temporal muscles during rest and bilateral mastication. (*Angle Orthod.* 2009;79:515–520.)

KEY WORDS: Electromyography; Masseter muscle; Temporal muscle; Morphology

INTRODUCTION

Based on the possibility of an interrelation between form and function, the masticatory muscles have been widely investigated in individuals with different vertical face characteristics. Their function and anatomy have been evaluated by electromyographic (EMG) exams,[1–9] bite force,[10] computed tomography of muscle thickness,[11] ultrasonography[5,12–15] and magnetic resonance,[16] in addition to immunohistochemistry evaluations of muscular fibers.[17]

EMG evaluations of masticatory muscles have produced divergent results when individuals with different vertical facial growth are compared. Some authors have observed that the amplitude of EMG values in temporal[1,2,6] and masseter[1,3,6] muscles is always greater in short-faced individuals. Some articles reported that the longer the face of an individual, the greater the EMG activity of the temporal muscle.[3,8] Still others report that this muscle activity does not present any correlation with vertical face morphology.[4] On the other hand, there are studies that do not show differences in the EMG activity of the masseter muscle when com-

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paring short-faced individuals to balanced or long-faced[5] individuals and when comparing normal individuals to hyperdivergent individuals.[8] According to Farella et al[7] and Cha et al,[8] the habitual activity of the masseter muscle does not seem to be influenced by the vertical craniofacial morphology.

With respect to the relevance of muscle function in the stability of orthodontic treatment, the aim of the present research was to study the EMG activity of the masseter muscle and the anterior portion of temporal muscles in individuals with different vertical facial types. The main difference between this research and similar previous studies is the use of statistical criteria to classify volunteers and the normalization procedure of the EMG signal.

MATERIALS AND METHODS

Seventy-eight volunteers received a clinical examination, cephalometric analysis, and EMG examination. All 78 were dental students or employees of Faculty Dentistry of Piracicaba and gave their informed consent. The examinations were conducted in accordance with the protocol (186/2006) approved by the Ethical Committee Research of the State University of Campinas.

The inclusion criteria were: complete permanent dentition with at least 28 teeth, absence of premature tooth loss, absence of anterior open bite, anterior and/or posterior cross bite, absence of orthodontic treatment of any nature, and absence of temporomandibular parafunctional habits. Only 44 volunteers (15 men and 29 women) between 18 and 35 years old met all the criteria for inclusion in the study.

The volunteers were evaluated for the presence of signs and symptoms of temporomandibular dysfunction by palpation of the joint area during opening and closing mouth movements, in addition to the lateral movements and palpation of muscles related to this joint (masseter, temporal, and lateral pterygoid).

Classification of Volunteers into Facial Groups

To classify the volunteers, lateral teleradiographs were used. The radiographs were evaluated in a room with reduced light. The cephalometric tracing on acetate paper was made by an orthodontist. The following anatomical structures were traced: external acoustic pore (pore point), orbit contour (orbital point), jaw (the mandibular plane was traced and the Gonial, Gnathic, and Mental points were identified), sella turcica (S point), and frontonasal suture (nasal point). After the anatomical structures were traced, the image was digitized,[18] and the FMA, SN.GoGn, and gonial (ArGoMe) angles were measured by the Radiocef 2000 cephalometric program, (Radio Memory, Belo Horizonte, Brazil).

Table 1. Pearson's Correlation Between the Variables SN.GoGn, FMA, and ArGoMe

	SN.GoGn	FMA	ArGoMe
SN.GoGn	1	.910	.679
FMA	.910	1	.754
ArGoMe	.679	.754	1

The volunteers were classified on the basis of their vertical face characteristics into the three groups brachyfacial (group 1; n = 13), mesofacial (group 2; n = 24), and dolicofacial (group 3; n = 7) by the grouping analysis. The grouping of the volunteers into these groups was obtained by multivariate statistical techniques (analysis of Pearson correlation, factorial analysis, and grouping analysis). The basis for constructing the Pearson correlation matrix, with a view to application of the factorial analysis, consisted of three cephalometric variables (SN.GoGn, FMA, and ArGoMe) obtained from the 44 radiographs of the sample. These variables, which expressed the vertical characteristics of the volunteers, were organized in a matrix form. The Pearson correlation test demonstrated a positive correlation between the variables SN.GoGn, FMA, and ArGoMe, according to Table 1. From the Pearson correlation matrix, the factorial analysis was used to summarize the covariance structure in order to provide grouping of the variables involved.

To group the individuals, the k-Means method was used, which is based on two premises: internal cohesion of the observational units and external isolation between the groups, ie, minimize the variance within the group and maximize the variance among groups. Calculation of the distances between the volunteers was based on the mean Euclidian distance measured by the factorial score variable obtained from reduction of the three original variables into one factor.

The factorial analysis technique summarized the three variables into only one factor that explained 85.53% of the total variance of the analyzed variables. The grouping method resulted in three distinct and homogeneous groups based on an ordinate factorial score for the 44 volunteers.

EMG Exam

The EMG examination was performed (without the knowledge of the grouping analysis result) with the purpose of recording the EMG activity amplitude of the masseter and temporal muscles, bilaterally.

To record the EMG signal, the 12-channel Myosystem I (Prossecon Ltd, Uberlândia, Brazil) was used, eight channels being for electromyography and four for support. The EMG signals were conditioned through programmable instrumentation amplifiers by software and analog filters: highpass of 20 Hz and lowpass of 1000 Hz. The signals were digitized with a frequency of sampling of 4000 Hz, with 12 bits of resolution and simultaneous sampling of signals. The signal visualization and processing were performed by Myosystem I version 2.12 software.

The EMG examinations were conducted at the electromyography laboratory at FOP-UNICAMP following the protocol described by Pedroni et al.[19] Simple, distinguishing, active electrodes (Lynx Electronic Technology Ltda, São Paulo, Brazil) were used to acquire the muscle's action potential. The electrodes were formed by two parallel rectangular bars (10 $\times$ 2 mm) made of pure silver (Ag) that were spaced at 10 mm and fixed in an acrylic resin measuring 23 $\times$ 21 $\times$ 5 mm. The electrodes had an input impedance of 10 G, a CMRR of 130 dB, and a gain of 20$\times$. Before placement of the electrodes, the skin was scrubbed using an alcohol-soaked gauze pad to reduce impedance between skin and electrodes.

To place electrodes, the function test was performed for each of the muscles. This test consisted of muscular palpation during simultaneous bilateral isotonic contraction, and the following positioning criteria were followed: superficial part of masseter (at muscular belly 2 cm above jaw angle) and anterior portion of temporal muscle at the muscular belly. A reference electrode made of stainless steel, the interface of which was soaked with water-based gel, was used to eliminate acquisition interferences.

At the EMG examinations, the individuals were seated with their heads guided in the Frankfurt Horizontal Plan, without being able to see the recordings on the computer monitor. The EMG recordings were obtained with three repetitions during mandibular rest, maximum voluntary contraction in intercuspidation (isometry), and simultaneous bilateral isotonic contraction, according to the following protocol:

— Rest for 5 seconds: the volunteer was instructed to relax facial muscles.
— Isometry for 5 seconds: the volunteer was instructed to bite in maximum habitual intercuspidation and maximum occlusion force with Parafilm M (American National Can, Chicago, Ill), measuring 15 $\times$ 8 $\times$ 3 mm, interposed on the occlusal surfaces of posterior teeth during 5 seconds. The Parafilm M must be folded into five equal parts and doubled over to its final length, according to Biasotto-Gonzalez,[20] who reported that this material reduced the variability of EMG signal values and could be considered the best material for recording EMG activity during chewing. The maximum potential obtained served as a reference value to normalize the EMG signal of the masseter and temporal muscles in the other evaluations.
— Simultaneous bilateral isotonic contraction: alternate "maximum" voluntary contractions and relaxations with a 1-Hz frequency for 10 seconds with Parafilm M. This acquisition was performed rhythmically by a calibrated metronome.
— EMG signals were processed by the equipment software in the time domain by the Root Mean Square calculation and expressed in μV.

Statistics Analysis

The statistical analysis was performed from the data for at rest and bilateral isotonic evaluations, which were normalized as a function of the isometric average values (reference value of each individual). The Kolmogorov-Smirnov and Levene tests were applied to verify the normality and homogeneity of variance. With the aim of identifying statistical differences between the studied groups, the analysis of variance was used for the data that presented normality and homogenous distribution, and the Kruskal-Wallis nonparametric test was used for those that did not attain the estimated normality and homogeneity. All statistical tests were done at a level of 5% for significance ($P < .05$).

RESULTS

Rest

Group 1 (brachyfacial) presented the lowest EMG values for the four muscles evaluated during rest when compared with groups 2 and 3. The right temporal and masseter muscles presented statistically significant difference among groups (Table 2).

The Kruskal-Wallis multiple-comparison test was applied to define differences between groups. Differences were observed between groups 1 and 2 ($P = .02$) and 1 and 3 ($P = .038$) for the right temporal muscle, and between groups 1 and 2 ($P = .029$) for the right masseter muscle.

Isotonic Contraction

For this evaluation, none of the muscles presented statistically significant differences among the groups (Table 3).

DISCUSSION

EMG studies with the aim of determining the relationship between masticatory function and facial morphology are still inconclusive. The criteria used to define vertical craniofacial morphology could be a possible explanation to these divergences.[7] Generally, facial types are defined by only one criterion: the ratio

Table 2. Descriptive Analysis and Kruskal-Wallis Test Value to Normalized Rest Variable for Muscle, for Each Group

	Group 1 (n = 13)		Group 2 (n = 24)		Group 3 (n = 7)		
Muscle	Mean	SE	Mean	SE	Mean	SE	*P*
LEFT TEMP[a]	0.022[b]	0.003	0.031	0.003	0.031	0.008	.296
LEFT MASS[b]	0.016	0.002	0.035	0.009	0.036	0.012	.078
RIGHT TEMP[c]	0.014	0.002	0.033	0.006	0.028	0.004	.007*
RIGHT MASS[d]	0.015	0.002	0.032	0.006	0.028	0.005	.021*

LEFT TEMP[a] indicates left temporal muscle; LEFT MASS[b], left masseter muscle; RIGHT TEMP[c], right temporal muscle; RIGHT MASS[d], right masseter muscle.

* Values in the table body lower than 0.05 indicate statistically significant differences among treatment means.

Table 3. Descriptive Analysis and *P*-Value to Normalized Isotonic Contraction Variable for Muscle, for Each Group

	Group 1 (n = 13)		Group 2 (n = 24)		Group 3 (n = 7)		
Muscle	Mean	SE	Mean	SE	Mean	SE	*P*
LEFT TEMP[a]	0.843	0.234	0.685	0.140	0.735	0.278	0.151
LEFT MASS[b]	0.749	0.208	0.708	0.144	0.739	0.279	0.848
RIGHT TEMP[c]	0.725	0.201	0.699	0.143	0.739	0.279	0.857
RIGHT MASS[d]	0.784	0.217	0.712	0.145	0.750	0.283	0.634

LEFT TEMP[a] indicates left temporal muscle; LEFT MASS[b], left masseter muscle; RIGHT TEMP[c], right temporal muscle; RIGHT MASS[d], right masseter muscle.

between the inferior and superior anterior facial height,[7] the angle formed between the mandibular plane and the base of the skull,[4] or the gonial angle.[1] In the present study, the definition of the groups is based on three cephalometric variables that present positive correlation. Incompatibilities of classification were observed when normative values were considered for classification of the facial types. Therefore, the use of statistical criteria gave the classification greater security.[21] By the grouping analysis, the volunteers were classified so as to minimize the variance inside the group and to maximize the variance among groups.

Another possible explanation for contradictions involves essential factors in EMG recording, in treatment of the signs, as well as in their interpretation. Although the normalization of EMG signals for comparisons between individuals is a recommendation of the International Society of Electrophysiology and Kinesiology, the majority of similar studies[1,8,9] used the raw data for such comparisons. This study normalized the values of rest and bilateral mastication, placing them in accordance with a reference value for the individual (isometric contraction). Thus, the comparison between volunteers became trustworthy. Consequently, the interindividual variations caused by differences in the thickness and electrical properties of the tissues present between electrodes and the evaluated muscle, as well as the muscle size and the position of the electrodes, were improved.[22–24]

Rest

The short-faced volunteers (group 1) presented the lowest percentile EMG values for rest evaluation, with statistical differences only for muscles on the right side. These results are in agreement with those of Cha et al,[8] who observed that the lower the mandibular plane, the lower the EMG activity of the temporal muscle. On the other hand, they are in disagreement with Ueda et al[3] and Cha et al[8] for the masseter, Ingervall and Thilander[1] for the temporal, and Tecco et al[9] for both muscles, in which the lowest EMG values are related to the highest values of vertical facial dimensions.

Even considering all these points, the percentile values for all muscles in the three groups were lower than 5% of maximum isotonic contraction during rest, thus not representing muscular hyperactivity.[25] If there is no hyperactivity, EMG values can be considered clinically normal for all groups. Moreover, if the mandibular rest is guaranteed by the viscoelastic properties of the muscles,[26] the signals obtained could be interference from the acquisition equipment or its installations.[27]

Isotonic Contraction

For isotonic evaluation, no statistically significant differences were observed for all the muscles among all the groups. These results agree with Farella et al[5] and Farella et al,[7] who studied only the masseter, and with those of Cha et al[8] and Tecco et al[9] for the masseter and the anterior portion of the temporal. However, Serrao et al[6] reported significantly lower EMG values for the temporal and masseter muscles for long-faced individuals when compared with those with short faces. Moreover, some studies observed negative correlation between the EMG activity of the temporal[1,2] and masseter muscles[1] and the vertical facial characteristics during mastication.

The lowest EMG activity observed in long-faced individuals[1,2,6] might be a consequence of occlusal instability and the presence of anterior open bite more than the craniofacial characteristics.[7] Some studies[7,28,29] reported a positive correlation between activity of the masticatory muscles and the number of occlusal contacts. In this research, however, the characteristics of dental occlusion and the number of occlusal contacts were not considered.

There are no reference values of EMG activity during rest or isotonic contraction for each facial type in the consulted literature. It is believed, however, that muscular function has an effect on facial morphology, but other factors, such as genetic and environmental, are involved. The EMG is an exam that tells us a great deal regarding the individualized evaluation of our patient. The innumerable interindividual variables make it difficult to interpret grouped data. The association with other exams, such as bite force and the size of the analyzed muscles, could provide more precise information about muscular behavior in individuals with different facial types.

Some might suggest that the sample size is too small to detect differences. According to Neyman's optimum distribution, when a level of confidence of 95% and a margin of error of 10% are considered, the sample was insufficient for group 2 (mesofacial; $n = 24$) for the right and left masseter muscles and right temporal muscle at rest, and for group 3 (dolicofacial; $n = 7$) only for the left masseter muscle at rest. This suggests that the dolicofacial group was more homogeneous in its characteristics, being an even smaller group than the mesiofacial group.

CONCLUSION

- Different vertical facial types did not determine distinct patterns of EMG activity for the masseter and anterior portion of temporal muscles during rest or bilateral mastication.

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