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Original Article

Artigo Original

Relationship between electrical activity of the temporal and masseter muscles, bite force, and morphological facial index

Relações entre potenciais elétricos dos músculos temporais e masseteres, força de mordida e índice morfológico da face

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Keywords

Stomatognathic System
Masticatory Muscles
Electromyography
Bite Force
Facial Morphology

ABSTRACT

Purpose: To analyze possible correlations between the electrical activity of masseter and temporal muscles, Bite Force (BF), and Morphological Facial Indices (MFI). **Methods:** The study involved 43 young adults, both genders, 18 to 37 years old. The individuals were submitted to: face measurement to calculate MFI; Masseter and Temporal Surface Electromyography (sEMG) and BF measurements on right and left premolars and incisors. The following electromyographic tests were conducted: at rest position; Maximal Voluntary Isometrical Contraction (MVIC) and usual chewing of raisins. Statistical analysis was conducted using the coefficient of Spearman correlation with significance level of 5%. **Results:** The values at rest in the temporal muscles were significantly higher than those in the masseter muscles. A meaningful correlation was found between MFI and sEMG in the MVIC test for the Left Temporal (r_s=36, p=0.017). A significant correlation was observed between FMI and sEMG during BF in incisors for temporal muscles and the Right Masseter. During the force tests, it was possible to observe a meaningful correlation between BF in right premolars and the sEMG of the Left Temporal and Masseters. **Conclusion:** No correlation was found between the sEMG of temporal and masseter muscles, BF, and FMI in adult individuals based on the tests performed. The SEMG of temporal and masseter muscles seems to be associated only with BF. As a datum of habitual postural characteristic, the electrical activity of temporal muscles is higher than the activity of masseters, also regardless of MFI.

Descritores

Sistema Estomatognático
Músculos Mastigatórios
Eletromiografia
Força de Mordida
Morfologia Facial

RESUMO

Objetivo: Verificar e analisar possíveis correlações entre a atividade elétrica dos músculos temporais e masseteres, a força de mordida e os índices morfológicos da face, em indivíduos adultos. **Método:** Participaram 43 indivíduos, adultos jovens de ambos os gêneros, entre 18 e 37 anos, submetidos à mensuração da face para cálculo do Índice Morfológico da Face (IMF), Eletromiografia de Superfície (EMGs) de Masseteres Direitos e Esquerdos (MD e ME), Temporais Direitos e Esquerdos (TD e TE) e obtenção da Força de Mordida (FM) nas regiões de pré-molares direitos, pré-molares esquerdos e incisivos. As provas eletromiográficas realizadas foram em repouso, Contração Voluntária Isométrica Máxima (CVIM) e mastigação habitual de uva-passa. Foi realizada análise estatística pelo coeficiente de correlação de Spearman com significância no nível de 5%. **Resultados:** Os valores de repouso em TD e TE foram significativamente maiores que os de MD e ME. Foi encontrada correlação direta significativa entre IMF e a EMGs na prova de CVIM para o TE (r_s=36, p=0,017). Observou-se correlação direta significativa entre o IMF com a EMGs durante a FM em Incisivos para os músculos TD, TE e Masseter Direito (MD). Durante as provas de força, foi possível observar correlação direta significativa entre a FM em pré-molares direitos com a EMGs do TE, MD, ME. **Conclusões:** Não foi verificada correlação entre as respostas elétricas dos músculos temporais e masseteres, a força de mordida e os índices morfológicos da face, em indivíduos adultos a partir das provas realizadas. A atividade elétrica dos músculos temporais e masseteres parece associar-se apenas à força de mordida. Como dado de característica postural habitual, a atividade elétrica dos músculos temporais é maior que a atividade de masseteres, também independente do IMF.

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INTRODUCTION

The mandible and its associated musculature play an important role in the functions of the stomatognathic system. They are related to various structures ranging from the temporomandibular joint (TMJ) and the oral structures to the elevator and depressor muscles of the mandible, which enable a variety of movements used in chewing, swallowing, and speech articulation.

Surface Electromyography (sEMG) has become an important complementary method in the search for a more comprehensive evaluation of the muscles of the stomatognathic system, because it captures information about the electrical activity of these muscles. sEMG can assist in determining conducts and demonstrating results obtained by specifically employed treatments, in addition to adding knowledge to studies on different facial and occlusal characteristics[1-3].

Likewise, assessment of Bite Force (BF) has been used in functional studies of the masticatory muscles. BF is influenced by several factors, and it can be measured, among other ways, using a load cell placed between the dental arches, which records the force being applied by the elevator muscles of the mandible[4,5].

The study of facial morphology is also of great importance for understanding the pathophysiology of the stomatognathic system. The functions of this system can occur in distinct ways in the various face types due to the relationship between hard and soft tissues, associated with genetic pattern and the various influences of craniofacial growth.

Considering that distinct facial types can define functional differences related to the dimensional aspects of the face, as well as to the muscular variations associated with these aspects[6-10], it seems appropriate to consider the existence of different behaviors of the elevator muscles of the mandible according to face morphology. Little is also known about the relationship of these variables during mastication, as well as about bite force. Thus the main issues underlying this study refer to possible changes in the behavior of temporal and masseter muscles with respect to electrical activity and bite force associated with variations in facial morphology, assuming that such changes would be expected.

One of the possible classifications of facial morphology refers to the Morphological Facial Index (MFI)[6], which is the centesimal ratio between the height of the face and its width, given by the bizygomatic diameter. According to this classification, MFI values[6] equal to or smaller than 78.9 correspond to an extremely short and wide face (hypereuryprosopic), whereas values equal to or greater than 93.0 indicate a very long and narrow face (hyperleptoprosopic). In a less exaggerated order, MFI values between 79 and 83.9 denote a short and wide face (euryprosopic), whereas a long and narrow face (leptoprosopic) presents values between 88 and 92.9. Faces showing harmony between height and width have MFI values ranging from 84 to 87.9 (mesoprosopic)[1].

Studies on MFI are available in the specific literature[7-10], but little can be found on the investigation of the associations between MFI and orofacial functions, or on its relations with electromyography of the masticatory muscles, or with BF.

Some studies[11-14] on different facial types using sEMG report a correlation between facial morphology and the electromyographic response of temporal (anterior bundle) and masseter muscles for some types of electromyographic tests[11-14].

The morphological features of the face and their association with BF are reported in some studies[15,16]. A study with children[15] showed a strong correlation between craniofacial morphology and BF only in boys, suggesting that this difference may be related to the different degrees of growth between genders. That study[15] discards correlation with the different occlusal situations, considering the Angle classification, as well as with variations of the head position. In a study involving Jordanian adults[16], researchers assessed BF in different facial types and identified significant differences between the facial patterns. The study shows that BF is smaller in individuals with long faces and greater in those with short faces[16].

Correlation between BF and sEMG was reported in a study[17] which observed a reliable association between electromyographic activity of the masseter and temporal muscles and BF in incisors and molars.

Based on the previously exposed facts, the investigation of the behavior of temporal and masseter muscles and the analysis of the possible correlations with respect to their electrical activity and BF, as well as with whether variations in facial morphology represent an interference, can provide guiding data for myofunctional characterization, especially for adults whose MFI are already fully defined and stable.

The purpose of this study was to investigate and analyze the possible correlations between the electrical activity of masseter and temporal muscles, bite force, and morphological facial indices. In this sense, it aims to seek data to improve understanding on the behavior of masticatory muscles that can contribute to the process of diagnosis and conduct of orofacial myofunctional disorders.

METHODS

The research was conducted at the Laboratory of Surface Electromyography of the Graduate Program in accordance with the protocol (CEP-203.381) approved by the Ethical Research Committee of the institution.

Forty-three consecutive subjects, young adults of both genders, aged 18-37 years (mean 24.2) participated in the study. The volunteers signed a free prior informed consent form.

The inclusion criteria were age range of 18-45 years and clinically healthy dentition.

The exclusion criteria were as follows: self-reported orofacial functional complaints; dental or occlusal abnormalities such as spaces due to anterior and/or posterior dental flaws, anterior or posterior open bite, and anterior or posterior crossbite; anteroposterior maxillomandibular disproportion; orthodontic treatment; facial trauma or surgery involving the musculoskeletal system of the face; symptoms and/or signs of temporomandibular disorders (TMD); or any other interfering health problem.

For verification of the inclusion and exclusion criteria, subjects underwent screening performed by three specialized Speech and language pathologists (SLP) with experience in Orofacial

Motricity, who jointly and immediately analyzed and discussed the compatibility of the volunteers submitted to the Protocol of Orofacial Myofunctional Evaluation and Anamnesis[18]. The verification of possible occlusal and/or skeletal alterations, as well as signs of TMD - identified in this study as exclusion criteria - was conducted through clinical inspection and joint analysis[18] by the SLP examiners.

Volunteers who met all the criteria for inclusion in the study were submitted to face measurement procedures, surface electromyography, and bite force measurement.

A digital pachymeter (Western PRO, DC-6 150 mm) adapted for bizygomatic reach was used to obtain the anthropometric data of the face. Assessment of the face was conducted with the individuals seated, with their teeth at normal intercuspal position, and their heads guided in the Frankfurt Horizontal Plan. The height and width of the face were recorded with three repetitions[18] by the same examiner, and the results found were used to calculate the arithmetic mean of these two variables. The respective obtained means configured the values considered for calculation of the MFI.

sEMG recordings and BF measurements were registered using the equipment Miotool 200/400 USB; 4 channels; 14-bit resolution; acquisition rate of 2000 samples per channel per second; noise <2 LSB; common mode rejection of 110 dB; and Data Acquisition System SDC500, MIOGRAPH software and USB 2.0, (Miotec Biomedical Equipment Ltda., Porto Alegre - Brazil) using a 20–500 Hz filter.

For acquisition of the sEMG signal, we used a disposable SDS 500 bipolar electrode positioned at fixed distance of 1.5 cm, manufactured in polyethylene foam with hypoallergenic medicinal adhesive, adherent solid gel, bipolar contact made of Ag/AgCl (silver/silver chloride) according to the recommended protocol[19]. The reference mono-polar electrode Meditrace™ 100 Pediatric Ag/AgCl, disposable, with solid gel (hydrogel) was used to eliminate acquisition interferences.

BF was assessed using a SDS1000 sensor connected to the previously mentioned Miotool system and a 20 mm diameter, 15 mm thick, 200 kg capacity load cell (bite-force transducer) Miotec® manufactured. The transducers were coated with PVC film and placed inside disposable latex finger cots, which were replaced at each test, thus fulfilling the basic criteria for biosecurity. Readings were recorded in KgF (Kilogram-Force).

Participants were instructed with respect to the sEMG and BF test procedures. Palpation of the face area was performed to identify the exact location to attach the electrodes. After that, the skin was prepared through gentle abrasion sanding; it was then cleaned with gauze soaked in 70 °GL alcohol[19].

Attachment of the bipolar electrodes was performed in parallel to the fibers on the temporal (anterior bundle, predominantly) and masseter muscles, bilaterally. The reference electrode was placed at the distal extremity of the right or left humerus bone[19]. The four sensors and the reference cord were eventually connected.

In all tests, examination gloves were used and discarded after the examination of each individual. All the procedures listed were performed by a single examiner. The review of procedures and recordings was performed immediately by two other examiners who monitored the tests, as in the previous work[20], aiming to ensure the correct completion of all phases. In case of non-agreement of the two evaluators with the examiner on the quality of the signal detected, the test was repeated until a general consensus about its quality was achieved.

The BF tests were performed in between the sEMGs in order to prevent the BF investigation from overburdening the muscles and, consequently, interfering with the results.

Description of the tests:

- Bite Force Measurement on Right (BFRP) and Left (BFLP) Premolars and Incisors (BFI). For the first BF measurement, the load cell was placed between the dental arches at the region of the right premolars. The participant was asked to accommodate the load cell in order to bite it in the central region. The participant was instructed to exert maximum bite force for five seconds, for three consecutive times, with rest intervals of also five seconds. The bite with the highest amplitude and regularity was chosen considering possible instabilities to bite exactly the center of the load cell. The procedure was completed by recording the average in Kgf (kilogram-force) for the central time period of two seconds of the selected bite.

The same procedures were followed for the region of the left premolars and incisors, but the measurement at the latter region was conducted five minutes after the electromyographic evaluation of mastication.

sEMG data were recorded during the BF measurements for later analysis of the relation between these two variables and between the sEMG during BF and the MFI. The period of two seconds of the selected test was considered for analysis of sEMG during BF. The same procedure was adopted for analysis in the three dental regions evaluated.

With regard to the units of measure, for purposes of comparison with other studies, values in Newton (N) and in Kilogram-force (Kgf) were referenced.

- sEMG testing: recordings were obtained in raw signal and analyzed in rectified signal - Root Mean Square (RMS).
- sEMG at habitual position (at rest): The participant was instructed to remain as relaxed as possible, without making any movement for fifteen seconds. The average of values in microvolts (μV) recorded for fifteen seconds were considered. Subsequently, these figures were normalized in order to obtain values in percentage[21].
- Maximum Voluntary Isometric Contraction (MVIC): Aiming to reduce possible occlusal interferences and register the MVIC, cotton rolls were placed in the intercuspal region of molars and premolars bilaterally to avoid direct contact between the maxillary and mandibular teeth. After that, the participant was instructed to bite the cotton rolls exerting maximum force on them, seeking a clenching of the teeth. Recording was conducted for five seconds at rest followed by five seconds at maximum clenching. Recording was performed in three repetitions with intervals of equal length between contractions. Using the raw signal, the three central seconds of the second clench were selected. The average values in μV from the RMS were considered for normalization.

- Habitual Mastication: The participant was instructed to habitually chew three raisings at the examiner's command. Test recording was conducted simultaneously with mastication, stopping after complete swallowing of the food bolus. The recording corresponding to the complete chewing, from first to last masticatory cycles, was selected and displayed in RMS to obtain the average in µV, which was subsequently used for normalization.

After this test, the participant remained at rest for five minutes before performing the MFI assessment.

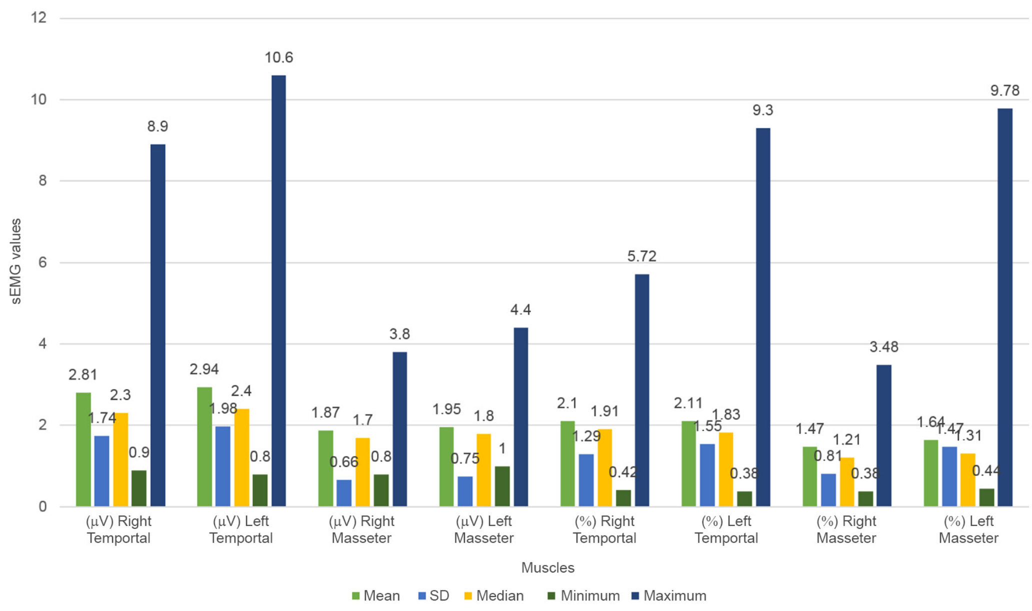
Statistical analysis

Inferential statistical analysis used the Spearman's correlation coefficient to verify significant association between the study variables. Nonparametric tests were applied to the variables that did not present Gaussian distribution because of large dispersion and rejection of the normality hypothesis according to the Kolmogorov-Smirnov and/or Shapiro-Wilk tests. All statistical tests were done at a level of 5% for significance (p<.05). The statistical analysis was process by the SAS 6.11 software (SAS Institute, Inc., Cary, NC).

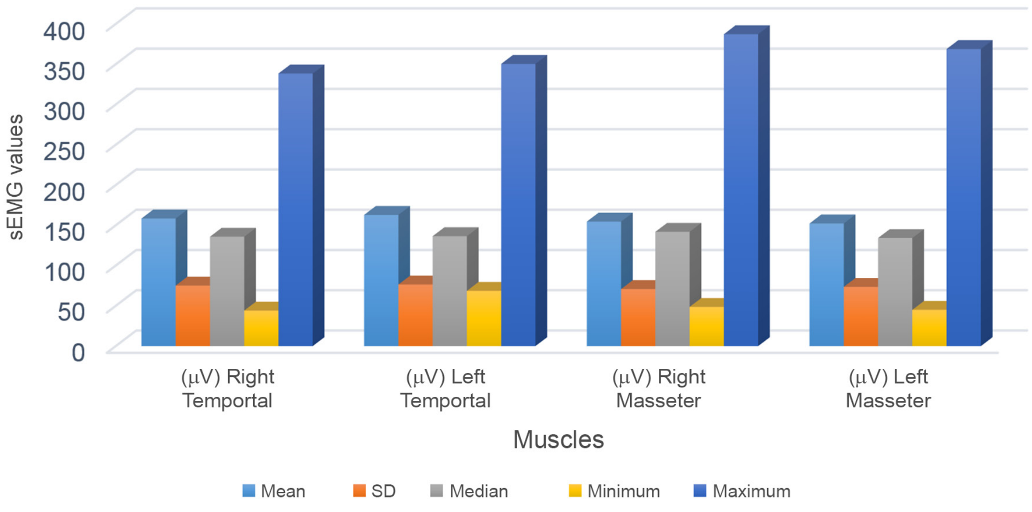
RESULTS

The MFI assessment showed predominance of hyperleptoprosopic participants (37.74%), followed by leptoprosopic (30.23%), mesoprosopic (11.63%) and euryprosopic (11.63%) individuals.

Regarding the sEMG, the descriptive presentation of the results in microvolts (µV) and in normalized data (%) is given in Graphics 1, 2 and 3.



Graphic 1. Description of data at rest, in microvolts (µV) and normalized (%)



Graphic 2. Description of the MVIC data

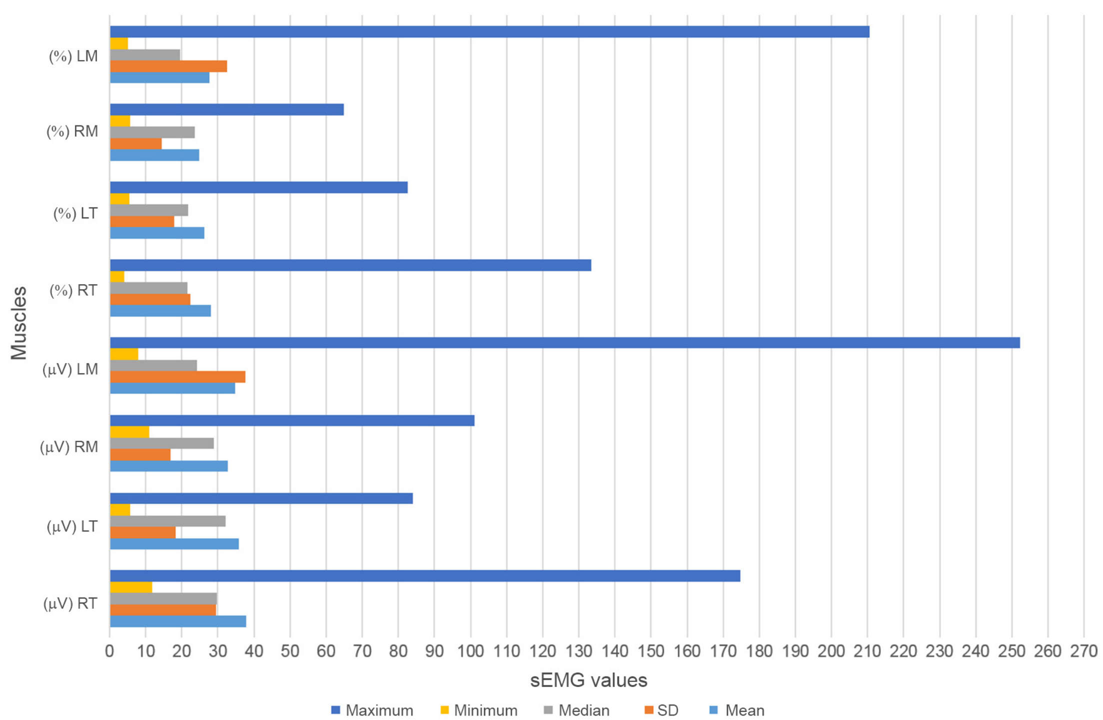
With respect to BF, Table 1 shows the descriptive presentation of the results in kilogram-force (kgf) and the sEMG data during execution of the bite force test.

Possible correlations between the variables were investigated by statistical studies. Table 2 shows the results regarding the relationship between the MFI and sEMG variables. Significant direct correlation was found between MFI and sEMG in the MVIC test only for the left temporalis (r_s=36, p=0.017).

Table 3 shows the study of the correlation between MFI and the BF variable. No correlation was found between the MFI score and BF in the dental regions analyzed.

Table 4 presents the correlation between MFI and sEMG. Significant direct correlation was observed between the MFI score and sEMG during the BF evaluation in the incisors for the left (LT) and right (RT) temporal and right masseter (RM) muscles, showing that the higher the MFI score, the higher the value in microvolts of the MVIC in these muscles.

As shown in Table 5, significant direct correlation was observed between BF in the right premolars and the sEMG of the LT, RM and LM muscles when the BF in the three regions analyzed is correlated with the percentage values (normalized) of the sEMG conducted during the force tests. These data indicate



Graphic 3. Description of mastication data, in microvolts (µV) and normalized (%)

Table 1. Description of the results of Bite Force in kilogram-force (KgF) and sEMG during the bite test, in microvolts (µV) and normalized data (%)

Variable	Mean		SD		Median		Minimum		Maximum	
	(µV)	(%)	(µV)	(%)	(µV)	(%)	(µV)	(%)	(µV)	(%)
BF - Incisors (KgF)	4.22		2.79		3.5		0.4		13.8	
sEMG – BFI (µV) – RT	60.4	44.7	53.9	41.9	45.2	30.4	14.3	7	225	180.4
sEMG – BFI (µV) – LT	66.8	44.5	47.7	29.0	50.2	34.1	14	10.4	208.9	119.4
sEMG – BFI (µV) – RM	73.6	52.3	35.1	26.1	67	47.6	11.6	13.6	172.7	121.9
sEMG – BFI (µV) – LM	71.9	52.3	38.2	33.1	62.2	45.9	9.2	18.7	200	181
BF – Right Premolars (KgF)	11.6		6.6		11.3		1.6		30.9	
sEMG – BFRP (µV) – RT	145.3	100.7	67.6	49.5	135.3	92.9	31.8	16.6	351.6	345.8
sEMG – BFRP (µV) – LT	118.0	79.4	57.5	40.3	109.1	70.2	10.1	13.4	282.3	232.5
sEMG – BFRP (µV) – RM	122.4	85.2	68.8	43.5	106.0	85.2	26.7	13.9	376.5	285
sEMG – BFRP (µV) – LM	124.4	87.1	62.8	33.5	108.3	80.5	25	34.5	340.1	176.1
BF – Left Premolars (KgF)	12.9		9.2		10.8		0.7		38.4	
sEMG – BFLP (µV) – RT	97.5	69.5	50.9	44.1	82.4	59.8	18.6	8.3	196.2	255.1
sEMG – BFLP (µV) – LT	148.5	100.5	55.2	39.6	151.1	94.2	29.3	29.7	280.8	247
sEMG – BFLP (µV) – RM	115.5	82.2	54.2	40.9	108	75.9	33.8	21.3	308.3	269.2
sEMG – BFLP (µV) – LM	115.8	82.6	55.0	38.9	107.9	77	22.1	35.7	271.1	252.7

Captions: BF: bite force; BFI: bite force in incisors; BFRP: bite force in right premolars; BFLP: bite force in left premolars; RM: right masseter; LM: left masseter; RT: right temporal; LT: left temporal

Table 2. Correlation between the MFI score and sEMG

Variable	r_s	p
At rest (μV) – RT	–0.024	0.88
At rest (μV) – LT	0.123	0.43
At rest (μV) – RM	0.189	0.23
At rest (μV) – LM	0.114	0.47
MVIC (μV) – RT	0.218	0.16
MVIC (μV) – LT	0.361	0.017
MVIC (μV) – RM	0.257	0.096
MVIC (μV) – LM	0.296	0.054
At rest (%) – RT	–0.289	0.061
At rest (%) – LT	–0.098	0.53
At rest (%) – RM	–0.143	0.36
At rest (%) – LM	–0.229	0.14
Mastication (μV) – RT	0.077	0.62
Mastication (μV) – LT	0.009	0.95
Mastication (μV) – RM	–0.079	0.62
Mastication (μV) – LM	–0.061	0.70
Mastication (%) – RT	–0.100	0.52
Mastication (%) – LT	–0.241	0.12
Mastication (%) – RM	–0.250	0.10
Mastication (%) – LM	–0.229	0.14

Captions: r_s: Spearman's correlation coefficient; p: level of significance; RT: right temporal muscle; LT: left temporal muscle; RM: right masseter muscle; LM: left masseter muscle

Table 3. Correlation between the MFI scores and BF

Variable	r_s	pP
Bite Force – Incisors (KgF)	–0.079	0.62
Bite Force – Right Premolars (KgF)	–0.109	0.48
Bite Force – Left Premolars (KgF)	0.141	0.37

Captions: r_s: Spearman's correlation coefficient; p: significance level; KgF: kilogram-force

that the greater the BF in the right premolars, the higher the percentage value (normalized) expected for the sEMG in the aforementioned muscles (Table 5).

DISCUSSION

Although we can currently count on advanced technology to accurately and reliably perform morphological evaluations[22-24], the use of pachymeters and other instruments to measure soft tissues have demonstrated their value owing to their fast and inexpensive application, as well as to the possibility of obtaining acceptably reliable measures, provided that the examiners have had prior theoretical and practical training[25-27].

Previous studies have investigated MFI both separately and together with other parameters, with different goals, including the attempt to demonstrate the unique morphological characteristics of some specific geographic regions and ethnic groups[7-10]. These studies have shown differences in the frequency of facial groups found according to the country or the region of a country studied, demonstrating that there is acceptable sensitivity regarding this index in the differentiation between some ethnic groups. In the present study, based on data from consecutive participants, we found prevalence of hyperleptoprosopic and leptoprosopic individuals. Despite the fact that the study was conducted in a single region (Rio de Janeiro), it is not possible to infer that the characterization of the MFI achieved reflects the ethnic factor of the local population, considering the small sample size.

Analysis of the relation between the MFI variables and the sEMG data investigated in this study showed a significant direct correlation in the MVIC test only for the left temporalis; it is not possible to interpret this datum considering that correlation is observed only for one of the muscles in only one of the sides.

Table 4. Correlation between the MFI scores and sEMG during BF

Variable	r_s	p
sEMG – Force - Incisors (μV) – RT	0.523	0.0003
sEMG – Force - Incisors (μV) – LT	0.354	0.019
sEMG – Force - Incisors (μV) – RM	0.365	0.016
sEMG – Force - Incisors (μV) – LM	0.240	0.12
sEMG – Force - Incisors (%) – RT	0.297	0.053
sEMG – Force - Incisors (%) – LT	0.141	0.37
sEMG – Force - Incisors (%) – RM	0.138	0.38
sEMG – Force - Incisors (%) – LM	–0.080	0.61
sEMG – Force - Right Premolars (μV) – RT	0.142	0.36
sEMG – Force - Right Premolars (μV) – LT	0.248	0.10
sEMG – Force - Right Premolars (μV) – RM	0.031	0.84
sEMG – Force - Right Premolars (μV) – LM	0.104	0.51
sEMG – Force - Right Premolars (%) – RT	–0.077	0.62
sEMG – Force - Right Premolars (%) – LT	–0.055	0.73
sEMG – Force - Right Premolars (%) – RM	–0.137	0.38
sEMG – Force - Right Premolars (%) – LM	–0.214	0.17
sEMG – Force - Left Premolars (μV) – RT	0.130	0.41
sEMG – Force - Left Premolars (μV) – LT	0.112	0.47
sEMG – Force - Left Premolars (μV) – RM	0.076	0.63
sEMG – Force - Left Premolars (μV) – LM	0.124	0.43
sEMG – Force - Left Premolars (%) – RT	–0.050	0.75
sEMG – Force - Left Premolars (%) – LT	–0.281	0.068
sEMG – Force - Left Premolars (%) – RM	–0.073	0.64
sEMG – Force - Left Premolars (%) – LM	–0.185	0.24

Captions: r_s: Spearman's correlation coefficient; p: significance level; RT: right temporal muscle; LT: left temporal muscle; RM: right masseter muscle; LM: left masseter muscle

Table 5. Correlation between BF and sEMG

Correlation			r_s	p
BF in Incisors (KgF)	x	sEMG (%) – RT	–0.194	0.21
	x	sEMG (%) – LT	0.039	0.80
	x	sEMG (%) – RM	0.033	0.83
	x	sEMG (%) – LM	0.139	0.37
BF in Right Premolars (KgF)	x	sEMG (%) – RT	0.253	0.10
	x	sEMG (%) – LT	0.504	0.0006
	x	sEMG (%) – RM	0.438	0.003
	x	sEMG (%) – LM	0.310	0.042
BF in Left Premolars (KgF)	x	sEMG (%) – RT	0.013	0.93
	x	sEMG (%) – LT	0.121	0.44
	x	sEMG (%) – RM	0.203	0.19
	x	sEMG (%) – LM	0.234	0.13

Captions: r_s: Spearman's correlation coefficient; p: significance level

Previous studies which also used normalized sEMG data have reported varying results. In a study that assessed different facial types[1], the authors found no relation between facial type and electrical activity in clenching, but found correlation in the right temporalis at rest. Such correlation at rest was reported in another study[13] which found differences in electromyography between different facial types. However, as in the present study, no correlation or differences were found during the isotonic contraction observed in mastication[13]. In this sense, the data obtained in this study are in agreement with those of the previous study[12], in which no correlation was found between the MFIs and electromyography during mastication and at rest. In contrast, some authors[27] have observed significant correlation between such variables both at rest and in the MVIC test for all analyzed muscles, and these data are not consistent with the results of the present study. It is worth noting that the studies aforementioned used different methods of facial assessment and electromyographic data collection, as well as different normalization procedures[22,28,29]. Those authors agree that the conversion of data in microvolts to percentage values, based on a specific maximum activation value (normalization), should be used to eliminate influences from the recording conditions of the electromyographic signal[22,28,29].

In this study, correlation between MFI and BF was also not observed in the dental regions assessed. A previous study[29] reported opposite results, concluding that facial morphology does influence bite force. Some authors[13] have also found significant differences between young subjects with short and medium, medium and long, short and long faces, demonstrating that facial morphology influences BF in these populations. In addition to influential factors, such as the relation between the nervous, musculoskeletal and dentoalveolar systems and mandibular biomechanics[4,5], several other factors can influence BF, e.g., age, gender, interocclusal distance, length and thickness of muscle, etc[5,15,29]. It should be noted that the cited studies were performed using different instruments and methods, which may have generated different mandibular positions and changes in the muscle length for more or for less of the ideal aspects during the bite[29], explaining the variations between the results of this and other studies.

With respect to the relation between MFI and sEMG during BF, no correlation was observed using the normalized values in the dental region examined. However, significant direct correlation was found between the MFI score and the sEMG data during BF in incisors, using absolute values in microvolts, in the RT, LT and RM muscles, showing that the higher the MFI, the greater the expected value in μV for these muscles during bite in the incisors. These data may clarify some doubts regarding differences between the studies analyzed[13,22,28,29], given that many of them presented non-normalized data, whereas others performed normalization.

In the present study, significant direct correlation between BF and sEMG was observed only during bite on the right side. The statistical analysis showed that the greater the force exerted, the higher the electrical activity in the LT, RM and LM muscles. This datum suggests that the impact of unilateral electrical activity in the temporal muscles is more closely related to the contralateral side, whereas it maintains bilateral influence on the masseter muscles. It is not precisely known what could justify this correlation on only one of the sides; the right side in the case of this study. The methods and instruments used and the results obtained do not provide data for analysis. Further studies are suggested for verification of the dominant side and detailed analysis of the occlusion, aiming to associate the items that may have influenced these results; studies involving specifically facial morphology and BF, with acquisition of electromyographic values not yet found that would enable greater explanations.

Considering that, in general, studies using surface electromyography present very high standard deviations, further research should be conducted with larger samples and grouping analysis of similar patterns. Also, studies specifically considering the anteroposterior maxillomandibular relation should be conducted to analyze whether this variable interferes in electrical activity and bite force.

CONCLUSION

Based on the methodology employed, we conclude that:

No correlation was found between the sEMG of temporal and masseter muscles, BF, and FMI in adult individuals based on the tests performed.

The sEMG of temporal and masseter muscles seems to be associated only with BF, and the greater the bite force in the region of premolars, the higher the electrical activity in the temporal muscle contralateral to the load and in both masseter muscles. However, this datum is observed only for bite force on the right side.

As a datum of habitual postural characteristic, the electrical activity of temporal muscles is higher than that of the masseter muscles, also regardless of FMI.

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Author contributions

DGM was the author of the master's thesis which generated the article; responsible for the bibliographical survey, data collection, analysis of results and statistical study, development of the work as a whole, as well as for the writing of the text under the supervision of his advisor; EMGB oriented the thesis and elaboration of the article; revised the data, directly or indirectly, at all phases of the study; monitored the results and the writing of the text.