

# Muscle activation time during chewing in temporomandibular disorder patients

## Tempo de ativação muscular em portadoras de disfunção temporomandibular durante a mastigação

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### ABSTRACT

**Purpose:** This study aimed to compare the time of masseter and anterior temporal muscle activations, in different ranges of surface electromyographic amplitude, between controls and individuals with temporomandibular disorders (TMDs) during mastication. **Methods:** Twenty-two female patients, aged 18-48 years, were divided into the TMD group (n=14; TMD type Ia, according to the Research Diagnostic Criteria for Temporomandibular Disorders) and the control group (n=8; non-diagnosed and asymptomatic individuals). Time and surface electromyography (SEMG) amplitudes from the anterior temporal and masseter muscles were registered during bilateral chewing of Parafilm M<sup>®</sup> for 10 s. SEMG amplitudes were categorized as 0-39%, 40-74%, and 75-100% of the mean of three maximal clenings. The percentages of total activation times (duty factor) in each range of SEMG amplitudes were compared between groups using an unpaired Student's *t*-test. **Results:** There were no differences in duty factor comparisons between groups. **Conclusion:** The activation time of the masticatory muscles was not found to be shorter in the TMD patients than in the controls. Finally, the application of the electromyographic variable proposed in this study may not be considered useful to diagnose type Ia TMD in clinical practice. However, its application may be complementary to the history and physical examination of these patients.

**Keywords:** Electromyography; Masticatory muscles; Temporomandibular Joint Dysfunction Syndrome; Mastication; Muscle contraction

### RESUMO

**Objetivo:** Comparar, entre portadoras de disfunção temporomandibular (DTM) e controles, o tempo de ativação do músculo masseter e do músculo temporal anterior, em diferentes faixas de amplitude eletromiográfica de superfície, durante a mastigação. **Métodos:** Foram avaliadas 22 voluntárias, com idades entre 18 e 48 anos, divididas em Grupo DTM (n=14) do tipo "Ia", de acordo com o *Research Diagnostic Criteria for Temporomandibular Disorders* (RDC/TDM) e Grupo Controle (n=8), assintomáticas. Foram registrados, por meio de eletromiografia de superfície, a amplitude e o tempo de ativação dos músculos masseter e temporal anterior, durante mastigação bilateral de Parafilm M<sup>®</sup> por dez segundos. Os sinais eletromiográficos foram categorizados em três faixas percentuais, 0-39%, 40-74% e 75-100%, relativas ao valor médio de amplitude de três contrações máximas de apertamento dentário. As porcentagens dos tempos totais de ativação (*duty factor*), em cada uma das faixas de amplitude, foram comparadas entre os grupos pelo teste t-Student, para dados não pareados. **Resultados:** Não houve diferenças significativas do *duty factor* na comparação entre os grupos controle e DTM. **Conclusão:** A variável eletromiográfica testada não se mostrou útil como ferramenta diagnóstica na prática clínica, o que será possível apenas quando em conjunto com a história clínica e exame físico do indivíduo.

**Descritores:** Eletromiografia; Músculos mastigatórios; Síndrome da Disfunção da Articulação Temporomandibular; Mastigação; Contração muscular

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**Conflict of interest:** No

**Author's contribution:** MBM main researcher, preparation of study schedule, survey of literature, data collection and analysis, manuscript writing, submission process; GSN assistant researcher, data collection and analysis, review of draft manuscript; NCP assistant researcher, data collection and analysis; ASO supervisor, conduction of research, preparation of study schedule, data analysis, review of draft manuscript, approval of the final version.

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## INTRODUCTION

Temporomandibular disorders (TMDs) comprise a group of musculoskeletal and neuromuscular conditions involving the temporomandibular joints (TMJ), the muscles used for mastication, and all associated tissues<sup>(1)</sup>. Causes for TMDs are complex and multifactorial, and may be related to predisposing, triggering, and perpetuating factors such as an occlusal condition, trauma, emotional stress, severe pain stimulation sources, and parafunctional activities<sup>(2)</sup>.

The signs and symptoms associated with these disorders are diverse and may include difficulties in chewing, speech, and other orofacial functions<sup>(1)</sup>. The most common manifestations also include acute or persistent pain; sensitivity in the mastication muscles, TMJs, and adjacent structures; limitations or deviations of mandibular movements; and cracking joints<sup>(3-5)</sup>. The chronic forms of TMDs can lead to absence from work and lack of social interaction, resulting in a general reduction in the quality of life<sup>(1)</sup>.

Many studies used surface electromyography (SEMG) in the evaluation of the masticatory muscles<sup>(6-8)</sup>, and this method allows for the demonstration of functions and dysfunctions of these muscles<sup>(9)</sup>. However, the usefulness of SEMG is controversial, especially when related to the diagnosis of TMDs<sup>(10)</sup>. It is believed that, if used in accordance with specific recommendations and in conjunction with clinical history and physical examination, SEMG generates documentable, objective data, which are also valid and reproducible, on the functional condition of an individual's masticatory muscles<sup>(11)</sup>. In addition, SEMG is a low-cost, non-invasive assessment technique that is easy to use<sup>(12)</sup>.

During normal chewing, performance depends on the association of several factors such as occlusion, maximum bite force, and chewing-cycle kinematics<sup>(13)</sup>. Most studies using SEMG on masticatory muscles are related to neuromuscular activation at rest or maximum clenching<sup>(14)</sup>. However, understanding the influence of TMD on normal chewing is essential, mainly because of its influence on the quality of life. As such, study of the electrical behavior during chewing, such as the activation time in different amplitude ranges, may bring more information about the motor control of individuals with TMD.

To analyze the difference in muscle activation time among groups, the working time during simultaneous bilateral chewing was compared. The working time or *duty factor*, a variable that has remained obscure in the literature, is described as the duration of muscle activity over or under a threshold pre-defined by the total electromyographic recording time<sup>(15)</sup>.

Compared with healthy individuals, those with TMD show less stability and less regularity in chewing cycles<sup>(16,17)</sup>. Previous studies demonstrated that orofacial pain in individuals with TMDs is associated with a slower and shorter amplitude of joint movements<sup>(18,19)</sup>. Psychological factors, often expressed through

depression or stress, also influence the association between pain and motor activity, probably as a protective factor developed by the individual<sup>(20)</sup>. Thus, differences in the EMG pattern among groups are expected, with shorter muscle activation time in individuals with TMD. This may be the key to using SEMG as a diagnostic tool in clinical practice.

Therefore, this study aimed to evaluate the activation time of the masseter and anterior temporal muscles during chewing in patients with TMD, using the working time or *duty factor* parameter in different amplitude ranges related to maximum muscular effort.

## METHODS

The study sample included 22 female individuals aged between 18 and 48 years. They were divided into 2 groups: the TMD group and control group. The TMD group had a mean age (standard deviation) of 28.5 years (8.6), and the control group had a mean age of 24.7 years (3.5).

Volunteer selection was performed through a telephonic interview including questions about intensity, duration and location of pain, use of braces, and absence of teeth, in addition to information on the volunteers' availability schedule. Then, they were divided into the TMD and control groups through the application of Axis I of the *Research Diagnostic Criteria for Temporomandibular Disorders* (RDC/TMD), proposed by Dworkin and LeResche<sup>(7)</sup>. The RDC/TMD clinical examination was duly adjusted and performed by a trained examiner in accordance with the guidelines of Dworkin and LeResche<sup>(7)</sup>.

The control group included individuals without signs and symptoms of TMD, according to the Axis I of the RDC/TMD<sup>(7)</sup>, who did not take muscle relaxants or antidepressants, and who had no other comorbidities such as headache or cervical pain. The control group excluded any person with bruxism or a TMD diagnosis per the RDC/TMD.

The TMD group included individuals with a diagnostic classification in group "1a" of the RDC/TMD, that is, myofascial pain without mouth opening limitations. Individuals with hypodontia, braces, fixed or removable prostheses, or a history of face trauma and TMJ dislocation/trauma were excluded from this study. Additional exclusion criteria for both groups included pregnant women; individuals with central and/or peripheral neurological disorders; those with a history of tumors; those with a history of surgery in the facial and neck region; those who were participating in any type of speech-language, dental, or physiotherapeutic treatment; those who were taking muscle relaxants or antidepressants; and those with pain in other body regions.

Twenty-five women that met the criteria were invited to attend the Laboratory for Posture and Human Movement Analysis at the Universidade de São Paulo, Ribeirão Preto for assessment of the inclusion and exclusion criteria in the

sample and data collection. Three patients were excluded after application of the diagnostic RDC/TMD questionnaire because they were classified in two distinct diagnostic groups and not only in group “la” (myofascial pain).

This study was approved by the Research Ethics Committee of the Hospital das Clínicas, Ribeirão Preto Medical School, Universidade de São Paulo (FMRP-USP), process n°. 12978/2011, in accordance with resolution 196/96 CNS/MS. All participants signed the Free and Informed Consent form.

## Procedures

Data was collected using SEMG following the standardization proposed by the *Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles* that allows data exchange and ensures the validity and reliability of the study<sup>(21)</sup>.

The myoelectric signals were captured through simple active differential surface electrodes of pure silver from EMG System Brasil® (São Jose dos Campos, Brazil). We also used a stainless steel reference electrode (Bio-Logic Systems® Corp) located on the sternal manubrium region, with the purpose of reducing the effect of electromagnetic and other noise interference during capture of the EMG signal.

The electrodes were placed on the volunteers' skin after being cleaned with cotton soaked in 70% alcohol, parallel to the muscle fibers, with the silver bars perpendicular to these fibers to maximize signal capture and minimize noise interference (Figure 1).



**Figure 1.** Placing the dynamometer and electrodes for bite force collection

According to the literature, the “working time” or *duty factor* variable is described as the percentage of total EMG recording time in which muscle activation was over or under a

pre-defined threshold, as measured by the EMG activity related to a certain level of bite force<sup>(15)</sup>. As such, it is important to use an instrument that pre-establishes bite force.

The instrument used to assess bite force was a digital dynamometer, model IDDK (Kratos®, Cotia-SP, Brasil), with a capacity of up to 100 Kg/f. The dynamometer was positioned on the first molars to obtain the greatest bite force. Three repetitions of maximum voluntary contraction were performed in maximum dental intercuspation during SEMG, with a 2-min interval between each repetition. The force peak of each collection was monitored on the dynamometer's digital display to ensure the consistency of effort in all three contractions. The SEMG signals of the masseter and anterior temporal muscles were collected during the repetitions using the Myosystem Br-1P84 (Datahominis®, Uberlândia-MG, Brazil). At the end of the procedure, the mean of the three EMG amplitude values was calculated to perform data normalization.

Standardized chewing data were collected with the volunteers sitting in a chair with their backs against the support, eyes open, feet on the ground, and arms resting on the lower limbs. The bilateral chewing record during contractions was then obtained; the volunteer was instructed to chew Parafilm M® (*Pechinery Plastic Packaging*, USA) placed between her pre-molars, first and second upper and lower molar, bilaterally and simultaneously for 10 s. A twice-folded Parafilm M® sheet was used on each side. The volunteers performed jaw elevation at a rhythm determined by a metronome set to 80 bpm, through the verbal command: “Bite, Bite, Bite...”<sup>(22)</sup>.

Data analysis was performed on the collected SEMG signal, considering 5 chewing cycles for each muscle (left anterior temporal, right anterior temporal, right masseter, and left masseter) of all volunteers. The mean duration of each cycle was approximately 0.3 s and the duration of each cycle was normalized from 0 to 100%.

The mean root mean square (RMS) value of the maximum contraction initially obtained, along with the results of the muscular strength test, was used as a reference for normalization of the amplitude values in each chewing cycle. The EMG signal amplitude was categorized into pre-established activation ranges<sup>(23)</sup>: 0-39.9% was considered minimal, 40-74.9% was considered maximum, and 75-100% was considered pronounced clenching amplitude.

From amplitude normalization, the amount of activation time in each above-mentioned range was added to represent the motor control strategy of each chewing cycle.

Descriptive statistical analysis was performed based on the mean values and standard deviations of the duty factor. The working time of 15 chewing cycles (5 cycles of 3 repetitions each) for each volunteer was considered. The comparisons made considered the intergroup analysis of the activation levels of each muscle. The statistical test for intergroup comparison was the Student's *t*-test for non-paired data, determined after verifying the normality of data distribution with the

Kolmogorov-Smirnov test. P values of <0.05 were considered statistically significant.

## RESULTS

The bite force and muscle activation time percentages in the different EMG activation ranges did not show significant differences ( $p>0.05$ ) among the evaluated groups.

The mean value of the bite force for the TMD group was 38.03 Kg/f and that of the control group was 42.93 Kg/f.

All muscles had a predominant activation time in the range of 0-39%, which suggested longer contraction time in the range classified as minimum activation, for both the TMD and control groups.

The results also revealed a similar pattern between groups regarding the distribution of normalized values in the maximum percentage range of activation time; all muscles showed shorter activation time, between 75% and 100%, characteristic of a concentric contraction.

The means and standard deviations of muscle activation time are compared between groups in Table 1.

## DISCUSSION

Available evidence in the literature demonstrate that arthrogenic and myogenic TMDs generate great influence on muscle activity during chewing, resulting in decreased activation levels<sup>(19)</sup>. Despite being insignificant, the small increase observed in the SEMG activation time of the control group may indicate a possible difference in the motor control strategy of the motor units, when compared with the group with “la”-type TMD. This difference can be identified using the *duty factor* tool and might be related to the symptoms and

changes in chewing function caused by TMD; therefore, its potential to distinguish between diagnostic groups should be further investigated. For example, its parameters are unknown in patients with isolated arthralgias.

The results found in this study could not be compared directly with those of previous studies because this study was the first to use working time or *duty factor* in individuals with muscle-generated TMD.

A previous study<sup>(15)</sup> evaluated the *duty factor* variable in 11 individuals with bruxism. Patients were divided into three groups: a group with disc displacement and pain, a group with disc displacement without pain, and another group without any change. For three consecutive days, the electrical activity of the masseter and temporal muscles was analyzed during wakefulness and sleep with SEMG portable recorders.

SEMG was calibrated to record the entire muscular activity over the threshold pre-established at 20 N of bite force. The *duty factor* for muscle activity >20 N in individuals with pain and disc displacement ranged from 8.5% to 13%; for sustained muscular activities (over 15 s), the *duty factor* mean was 9.4%. However, no significant outcome was observed because groups did not include seven people each, which was the number of participants that the power analysis ( $\alpha=0.05$ ,  $\beta=0.80$ ) indicated as necessary for each diagnostic group for applying the variable. The results of the present study with a larger sample size also showed no differences in the muscle activation time between individuals in the control group and those in the TMD group. However, data were analyzed in only two activation ranges, one >20 N and one <20 N of clenching; in this study, activation levels were weighted against maximum effort.

It should also be considered that despite using more than seven volunteers as proposed previously<sup>(15)</sup>, the sample size

**Table 1.** Differences in mean and standard deviations of muscle activation time

Muscles	0-39.9%			40-74.9%			75-100%		
	TMD vs. Control	Mean difference	CI 95%	TMD vs. Control	Mean difference	CI 95%	TMD vs. Control	Mean difference	CI 95%
	Mean (SD) (s)	(SD) (s)		Mean (SD) (s)	(SD) (s)		Mean (SD) (s)	(SD) (s)	
Right temporal	137.3 (30.54)			86.6 (34.70)			49.5 (15.63)		
	vs.	43.23 (31.99)	29.96-116.42	vs.	14.62 (12.64)	11.75-41.00	vs.	4.21 (6.04)	8.40-16.83
	94.1 (9.50)			72.0 (24.57)			45.2 (12.4)		
Left temporal	112 (21.11)			83.3 (25.87)			46.3 (7.92)		
	vs.	6.0 (25.73)	47.68-59.68	vs.	1.05 (15.73)	33.86-31.76	vs.	2.83 (6.05)	15.53-9.85
	106 (15.27)			84.4 (39.7)			49.2 (20.08)		
Right masseter	120.2 (19.34)			80.2 (26.42)			45.0 (7.54)		
	vs.	7.67 (22.09)	38.40-53.76	vs.	4.25 (12.29)	29.89-21.39	vs.	3.14 (4.41)	12.35-6.06
	112.5 (12.5)			84.5 (28.43)			48.1 (11.04)		
Left masseter	121.1 (14.11)			94.7 (27.36)			51.1 (10.69)		
	vs.	31.26 (18.96)	8.29-70.82	vs.	24.82 (12.62)	1.51-51.15	vs.	7.69 (5.85)	4.52-19.91
	89.8 (11.82)			69.9 (29.07)			43.4 (14.39)		

**Note:** TMD = temporomandibular disorder; SD = standard deviation; CI = confidence interval of 95%; s = seconds; vs. = versus



of the present study may have been insufficient to achieve the expected results. Future research with a greater number of women may bring some statistically relevant information.

Based on the results of this study, it is clear that SEMG alone cannot distinguish between healthy individuals and those with TMD<sup>(11,24)</sup>. However, this variable may bring some additional information about the strategy used by the neuromuscular system to perform muscular contractions, such as increase or decrease in muscle activation time in a certain amplitude range. This may help to identify situations of hyper- or hypoactivation resulting from reflex inhibitions caused by pain or protective spasms<sup>(18)</sup>. Thus, these results support the interest of including the *duty factor* along with clinical history and physical examination to investigate whether the activation time can play a part at the therapeutic approach; moreover, this would assist in identifying effective techniques that promote or reduce muscle activation.

## CONCLUSION

The use of objective data obtained with SEMG as a diagnostic tool in clinical practice will only be possible if combined with both clinical history and physical examination of the individual.

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