# Frequency of electromyographic indices alterations in temporomandibular disorders and their correlation with pain intensity*

*Frequência de alterações dos índices eletromiográficos na disfunção temporomandibular e sua correlação com o nível de dor*

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## ABSTRACT

**BACKGROUND AND OBJECTIVES**: Understanding the importance of surface electromyography as a complementary method to understand the myofunctional status of the stomatognathic system, this study aimed at analyzing the frequency of altered and normal electromyographic indices in a sample of subjects with temporomandibular disorders, in addition to their relation with pain complaint.

**METHODS**: Participated in the study 44 individuals with temporomandibular disorder signs and symptoms (11 males and 33 females), with mean age of 39 years, who were submitted to surface electromyography. Pain intensity was measured by the visual analog scale. Total Asymmetry Index (AStotal), Masseter Asymmetry Index ($AS_{MM}$), Temporal Asymmetry Index ($AS_{TA}$), Activation Index (ACtotal) and Torque Index (TOtotal) were calculated. Correlation between pain intensity and electromyographic indices was checked by Pearson correlation test and sample characterization with regard to investigated indices was done by descriptive analysis.

**RESULTS**: Means of all indices were within previously established normality patterns. The frequency of altered electromyographic indices in our sample was high ($AS_{MM}$=68%; $AS_{TA}$=64%; TOtotal=64%; AStotal=55%). With regard to ACtotal, there has been predominance of masseter activity as compared to temporal activity, both for normal and altered values. Among individuals with altered indices, the left side had superior activity. No correlation was found between pain intensity and the level of electromyographic indices alterations (p>0.05).

**CONCLUSION**: The frequency of electromyographic indices alterations in individuals with temporomandibular disorders is high, pointing to the possible presence of myofunctional disorders of the stomatognathic system. These indices have no direct relation with pain complaint but show muscular activity imbalance, which may not be useful to diagnose pain, but may help the correct referral to relevant muscle therapies.

**Keywords**: Electromyography, Masticatory muscles, Orofacial pain, Temporomandibular joint disorder syndrome.

## RESUMO

**JUSTIFICATIVA E OBJETIVOS**: Compreendendo a importância da eletromiografia de superfície como método complementar para o entendimento do estado miofuncional do sistema estomatognático, o objetivo deste estudo foi analisar a frequência de índices eletromiográficos alterados e normais em uma amostra de sujeitos com disfunção temporomandibular, bem como sua relação com a queixa de dor.

**MÉTODOS**: Foram avaliados 44 sujeitos com sinais e sintomas de disfunção temporomandibular, (11 homens/33 mulheres), com média de idade de 39 anos, os quais foram submetidos à eletromiografia de superfície. O nível de dor foi investigado por meio de escala analógica visual. Foram calculados o Índice de Assimetria Total (AStotal), Índice de Assimetria do Masseter ($AS_{MM}$), Índice de Assimetria do Temporal ($AS_{TA}$), Índice de Ativação (ACtotal) e Índice de Torque (TOtotal). A correlação entre o nível de dor e os índices eletromiográficos foi verificada pelo teste de correlação de Pearson e a caracterização da amostra quanto aos índices investigados foi feita por meio de análise estatística descritiva.

**RESULTADOS**: As médias de todos os índices encontraram-se dentro dos padrões de normalidade, estabelecidos previamente. A frequência de índices eletromiográficos alterados na amostra estudada foi alta ($AS_{MM}$=68%; $AS_{TA}$=64%; TOtotal=64%; AStotal=55%). Em relação ao ACtotal houve predomínio de atividade do masseter em relação ao temporal, tanto para os valores normais quanto para os alterados. Dentre os sujeitos com índices alterados, o lado esquerdo apresentou atividade superior. Não foi encontrada correlação entre o nível de dor e o nível de alteração dos índices eletromiográficos (p>0,05).

**CONCLUSÃO**: A frequência de alterações dos índices eletromiográficos em sujeitos com disfunção temporomandibular é elevada, apontando para a possível presença de distúrbios miofuncionais do sistema estomatognático. Esses índices não têm relação direta com a queixa de dor, mas revelam a existência de um desequilíbrio na atividade muscular, que pode não ser útil para o diagnóstico da dor, mas sim para o correto encaminhamento às terapias pertinentes voltadas para a musculatura.

**Descritores**: Dor orofacial, Eletromiografia, Músculos mastigatórios, Síndrome da disfunção da articulação temporomandibular.

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## INTRODUCTION

Orofacial pain includes temporomandibular disorders (TMD), conditions in which multiple painful conditions are added, generating body maps of pain which are as or more important than pain reported in the primary complaint[1]. TMD is primarily diagnosed by clinical investigation. A well conducted history is able to orient 70% of the diagnostic reasoning which is in general concluded with the dental clinical exam. Additional exams, such as imaging, contribute to elucidate doubtful diagnoses for the adequate decision-making process[2].

Painful sensation investigation is critical for accurate pain classification. For such, analog, numeric and qualitative scales were developed and, added to palpation, help characterizing patients' sensation. Currently, pain threshold to pressure may be considered normal or indicate altered sensitivity, according to values established by previous studies[3,4].

Surface electromyography (EMG) aims at evaluating neuromuscular activity and may contribute to the definition of relevant therapies in different TMD cases, when judiciously used and added to orofacial myofunctional investigation. This investigation aims at studying the functions of chewing, swallowing and speaking, in addition to muscular situation needed to perform such functions. Changes in such structures and/or functions characterize an orofacial myofunctional disorder[5].

Some authors suggest better understanding of possible relationships between pain and stomatognathic system status, because muscular recruitment could be affected as a way to compensate for the presence of pain[5,6].

In the clinical practice, surface EMG allows understanding stomatognathic system neuromuscular recruitment in different activities and also the evaluation of proposed treatments[7]. A previous study[8] has developed electromyographic indices able to evidence different relationships between masseters and anterior temporal muscles. Among such relationships it has established Asymmetry Index (asymmetry between masseters and contralateral anterior temporal muscles) and Activation Index (asymmetry between pairs comparatively), for which normality standards were established as reference for clinical-scientific application[9]. So, when there is neuromuscular balance, expressed by means of EMG, this is interpreted as healthy and stable muscular activity[10] from the point of view of this exam, and should be added to clinical results for a conclusive opinion.

When reviewing the literature on TMDs, it is possible to understand that electromyographic exam has low specificity and is not adequate as diagnostic method for this clinical condition[11-13]. The same exam shows electric activity status of masticatory muscles, providing an understanding about the energy required by such muscles to supply stomatognathic system functional demand. So, a study aiming at investigating the frequency of electromyographic alterations in a TMD case series, would add information to the literature about the real usefulness of this tool, as it happens in cases needing referral for specific evaluation of stomatognathic functions and speech therapy, and not informing TMD diagnosis and severity.

Understanding that TMDs in general influence stomatognathic system muscle functions, this study aimed at evaluating the frequency of altered and normal electromyographic indices in a sample of TMD patients, as well as their relationship with pain complaint, which is their primary symptom.

## METHODS

This is an observational descriptive crossover study evaluating 44 patients with mixed TMD (disc disorders associated to masticatory muscles disorders) according to information obtained during history and added to clinical findings, being 11 males and 33 females, with mean age of 39 years (16 to 65 years). Diagnostic clinical investigation was carried out according to guidelines of the American Academy of Orofacial Pain, which proposes the major structure of the International Headaches Classification, which places TMD in the 11th category, with some adaptations of terminology and category subdivisions[2].

Participated in the study patients with at least 28 natural teeth or with minor restorations. Users of total prostheses, with lack of dental elements, who had suffered tumors or major surgeries (grafts, orthognathic surgery) in head and neck region, in addition to patients being submitted to different treatments related to the stomatognathic system (dental treatments, speech therapy, others) were excluded.

All individuals who accepted to participate have signed the Free and Informed Consent Term and were submitted to surface EMG with the Myotrace 400 (Noraxon®) equipment. EMG recording and analyses were carried out according to equipment's own protocol, using disposable silver/silver chloride bipolar surface electrodes with diameter of 10 mm and distance between electrodes of 21±1mm (Hall Indústria e Comércio LTDA®). After cleaning the skin with 70º alcohol, electrodes were placed on parallel bundles of muscle fibers (TD, TE, MD and ME) and one disposable reference electrode was placed approximately 10 mm above the glabella.

Electromyographic exam was performed in a silent room with dim lights and with patients sitting on comfortable chair having their feet flat on the floor, back supported by the backrest and gaze parallel to the floor ("at the horizon") and was made up of six stages[13]:

1. Baseline/Postural Evaluation - Seated: subjects were oriented to sit comfortably with legs in position of 90º with relation to floor and with Frankfurt occlusal plane parallel to the floor, eyes directed to a fixed point ahead and arms relaxed over the legs, remaining at rest for 10 seconds. This stage evaluates the amount of muscular energy used by the individual to keep the jaw in the resting position;
2. Baseline/Postural Evaluation - Standing: subjects were oriented to stand up and remain standing up comfortably looking to a fixed point ahead, in resting position for 10 seconds. This stage evaluates the activity between homologous pairs and the relative activity between muscle groups when there is change in position from sitting down to standing up;
3. Funtional Clench: subjects were oriented to sit in the initial resting position according to the 1st stage and perform a maximum teeth clench for 2 to 3 seconds, twice, in a 10-second in-

terval. This stage is used to investigate functional relationship between agonists, antagonists and the synergy of masticatory muscles during maximum usual intercuspal position (MUI);
4. Funtional Control: this stage has the same objective and is performed similarly to the previous stage, however with interposition of cotton roll (MasterRoll, Wilcos®, Germany) between superior and inferior premolars. This stage provides data on the maximum normalization effort (MVC) and is a basis for comparison among other values;
5. Swallow: individuals sitting down in the initial resting position were oriented to hold a glass of water and drink a small amount, returning the glass to the position in which the arm is in approximately 45º forward and swallow. Swallowing process was repeated twice in a 10-second interval. This stage evaluates the presence of hyper or hypoactivity with regard to antagonist muscles and muscle synergy, as well as the relationship between the time involved during the process;
6. Long Clench: then individuals were oriented to perform maximum clench during 10 seconds, with constant examiner verbal encouragement to prevent the level of applied strength to decrease. This stage of the electromyographic exam evaluates whether there is muscle fatigue during prolonged effort and which muscles are involved in this fatigue condition. Values used in this research were related to frequency analysis (mean frequency – Hz).
Initial resting position in all stages was important to prevent the effect of any fatigue, and a resting period of at least 3 minutes was allowed between each test.
This study has used data regarding Functional Clench (uV) of evaluated muscles. After data collection, Total Asymmetry Index (AStotal), Masseter Asymmetry Index ($AS_{MM}$), Temporal Asymmetry Index ($AS_{TA}$), Activation Index (ACtotal) and Torque Index (TOtotal), described by Naeije, Mccarrol and Weijs[8], were calculated.
Pain was measured with the visual analog scale (VAS). These data were correlated to electromyographic indices by Pearson Correlation test, with significance level of 5%. Descriptive statistics was used to analyze electromyographic data to characterize the sample.
This study was approved in research project by the Ethics Committee, School of Dentistry of Ribeirão Preto (FORP/USP) under protocol 08982312.6.0000.5419/2013.

## RESULTS

Mean and standard deviation obtained for each electromyographic index were, respectively: 16%±13% for AStotal, 18%±14% for $AS_{MM}$, 25%±22% for $AS_{TA}$, 26%±17% for ACtotal and 15%±13% for TOtotal. These data are shown in table 1 which also shows data related to minimum, maximum and normality values for each index.
Frequencies of altered and normal electromyographic indices are shown in figure 1. With regard to AStotal, 55% of subjects with TMD had altered values, while 45% were normal. For $AS_{MM}$, 68% were altered and 32% were normal, and for $AS_{TA}$, 64% altered and 36% normal. TOtotal values were 64% altered and 36% normal, while for ACtotal there has been more activity of masseter muscles as compared to temporal muscles. Among

**Table 1.** Minimum, maximum, mean, standard deviation and normality values of electromyographic indices[9]

| Indices | Minimum | Maximum | Mean | Standard deviation | Normality value |
|---|---|---|---|---|---|
| Total asymmetry (%) | 1 | 50 | 16 | ±13 | Up to 10 |
| Masseter asymmetry (%) | 2 | 53 | 18 | ±14 | Up to 10 |
| Temporal asymmetry (%) | 1 | 82 | 25 | ±22 | Up to 10 |
| Activation (%) | 1 | 66 | 26 | ±17 | Up to 15 |
| Torque (%) | 0 | 58 | 15 | ±13 | Up to 10 |

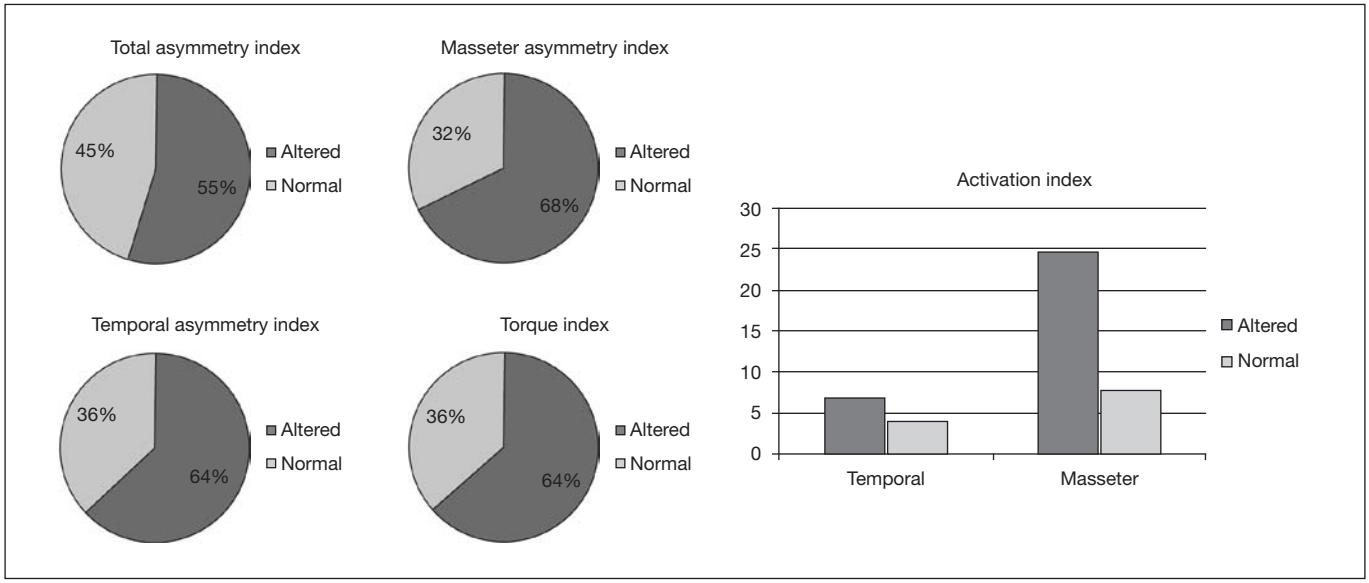


**Figure 1**. Relative normality and alteration frequency of electromyographic indices in subjects with temporomandibular disorder

subjects with higher masseter activity, 25 had altered values and 8 normal values; among those with higher temporal activity, 7 subjects had alteration and 4 were within normality standards.

Figure 2 shows the relative frequency of alterations found in electromyographic indices with regard to sides of the face. For AStotal, $AS_{TA}$ and TOtotal there have been more alterations on the left side of the face as compared to the right. For $AS_{MM}$ there has been proportion of alteration between face sides.

There has been no correlation between level of pain (determined by VAS) and level of electromyographic indices alterations (Table 2). For AStotal, statistical values obtained were r=-0.06 and p=0.69; for $AS_{MM}$, r=0.09 and p=0.55; for $AS_{TA}$, r=0.11 and p=0.46; for Actotal, r=0.1 and p=0.51 and for Tototal, r=0.01 and p=0.9.

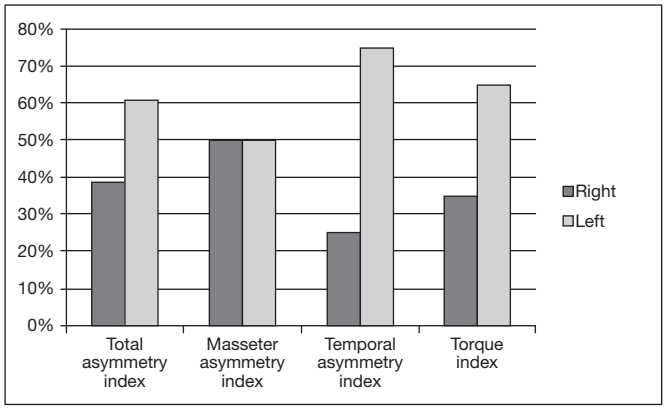


**Figure 2**. Relative frequency of alterations found in electromyographic indices for right and left sides of the face. Note the only subjects with altered indices were considered for this analysis

**Table 2.** Correlation between visual analog scale and electromyographic indices (Pearson)

| | r (Pearson) | p value |
|---|---|---|
| Total asymmetry | -0.06 | 0.69* |
| Masseter asymmetry | 0.09 | 0.55* |
| Temporal asymmetry | 0.11 | 0.46* |
| Activation | 0.10 | 0.51* |
| Torque | 0.01 | 0.9* |

*Without statistical significance (p>0.05)

## DISCUSSION

Pain is the major TMD symptom and in general is the reason why people look for professional help. To accurately diagnose pain, it is necessary a deep investigation about pain characteristics, in addition to measuring it. Different psychophysical scales were developed to measure pain, being VAS one of the most popular scales[3]. According to this scale, all subjects of our sample had orofacial pain as major reason for looking for treatment.

Surface EMG aims at studying bioelectric phenomena occurring in skeletal muscle fibers during maximum contraction, rest and effort, and has been used to functionally evaluate neuromuscular system which may or may not be altered by pain, providing additional diagnosis about active stomatognathic system[10]. So, it contributes to the establishment of approaches to treat myofunctional changes, since other TMD alterations, in addition to pain, such as masticatory, swallowing, speech and rest alterations also need specialized attention for the subject to be contemplated in a broader spectrum and to present a condition resolution with more stability and less probability of recurrences[5,11].

Muscular conditions are the most frequent TMDs. Most frequent reported symptom in TMDs is pain of muscular origin, be it localized or referred[2]. When nociceptive stimuli are sent to the somatosensory cortex, there is a response or motor reflex in skeletal muscles which is expressed by contraction, generating a self-sustainable pain-muscle contraction cycle[2].

In our study, mean values of all electromyographic indices were above established normality standards[9], as observed in table 1. The frequency of alteration in $AS_{MM}$, $AS_{TA}$ and Tototal indices was similar, around 66%. Similar results were found where subjects with chronic TMD had more asymmetry in the electromyographic activity of anterior temporal muscles as compared to control subjects[12].

In spite of this, and of the fact that the whole sample had orofacial pain, not all had alterations in electromyographic indices values and there has been no correlation between pain level measured by VAS and level of alteration of such indices. A study[13] has not found evidences to prove the existence of any difference detected in the electromyographic activity in painful and non-painful areas of masticatory muscles in subjects with unilateral myofascial pain. Authors discussed that central adaptation mechanisms could explain such findings and that muscle disorders diagnosis by electromyography has low specificity and should be made with caution[13].

When thinking about TMD, the relationship between orofacial pain and electromyographic alteration seems to be direct or obvious, since compensatory mechanisms for pain relief may change muscle recruitment during static and dynamic muscle contractions[5,6]. However, this direct relationship is not true, because in addition to possible compensatory muscular mechanism, different neurobiological and biopsychosocial factors, such as pain modulation, central sensitization, stress, comorbidities, genetics, among others, involve pain sensation and should be taken into consideration[14,15]. These other factors, considered as body systems similar to the musculoskeletal system, would possibly explain the part of the sample which, although with pain, had no electromyographic indices alterations.

EMG to diagnose muscle alterations should never be used alone, as single evaluation tool. This exam gives data on stomatognathic system neuromuscular functioning and contributes for necessary referrals, such as speech therapy and physiotherapy, specialties which use electromyographic data to complement therapeutic planning. In this sense, the electromyographic evaluation performed in these patients has allowed to differentiate who needed such referrals, that is, it gave hints about possible contributing factors for TMD global presentation and not about its diagnosis,

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which is not the objective of EMG because it does not meet reliability and validity standards needed for this purpose[13,15].

## CONCLUSION

The frequency of electromyographic indices alterations in subjects with TMD is high, pointing to the possible presence of stomatognathic system myofunctional disorders. These indices are not directly related to pain complaint, but show the existence of muscle activity imbalance, which may not be useful for the diagnosis of pain, but rather for the correct referral to relevant muscle-related therapies.

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