USUAL CHEW AND ELETROMYOGRAPHIC ACTIVITY OF THE MASSETER AND TEMPORALIS MUSCLES IN SCHOOL CHILDREN FROM 7 TO 12 YEARS

Mastigação habitual e atividade eletromiográfica dos músculos masseter e temporal em escolares de 7 a 12 anos

Diodete Grisi Bacelar Garcia[1], Silvia Damasceno Benevides[1], Roberto Paulo Araujo[2], Camila de Oliveira Ribeiro[2], Sandra Maria Ferraz Mello[3]

ABSTRACT

Purpose: to investigate the relationship of the masticatory preference side in the electrical activity of masseter and temporalis muscles. **Methods:** the sample was composed by 115 children aged between 7 and 12 years. The acquisition of the electrical activity of the masticatory muscles was recorded during 5 seconds of isometric contraction in maximal intercuspal position. The children were divided into four groups according to masticatory preference observed: Chewing Preferential Right, Left, Bilateral Alternating, and Bilateral Simultaneous. The electromyographicdata were analyzed using the SPSS 17.0 software, and for determination of statistical difference between the electrical activity of the right and left masseter and temporalis muscles was performed by Paired Student t-test ($p < 0.05$). **Results:** from the total of 115 children, 76 (63.4%) had a preferred side during mastication, whereas 44 (36.7%) children had masticatory right and 32 (26.7%) preferred chewing left. Of the individuals without a preferred side, it was found 25.8% (n = 31) alternating with bilateral chewing and 10.8% (n = 13) with simultaneous bilateral chewing. After comparing the electrical activity of the masseter and temporal, right and left, according to the group chewing, it was found that the average electrical activity of the muscles on the left side showed no statistically significant differences when compared with the average of its peers right side. **Conclusion:** for the study sample, there was no relationship between the habitual chewing side and electrical activity of the muscles masseter and temporal.

KEYWORDS: Mastication; Child; Students; Electromyography; Masticatory Muscles

NTRODUCTION

Chewing is considered by many authors as one of the most important and most studied functions of the stomatognathic system[1,2]. When performed in a alternating bilateral way, there is synchrony of masticatory muscles, which in turn are crucial for the stimulation of supporting structures, such as bones and teeth and for favoring that the harmonious craniofacial growth occurs[3] .

The chewing pattern can be influenced by several factors, such as occlusal interferences, dental and/or periodontal problems, tooth loss, muscle and/or temporomandibular joints problems[2].

It is known that in a unilateral mastication, the chewing muscles are mainly characterized by increased muscle strength on the working side, in other words, where chewing is occurring. The muscles of the balancing side, opposite side to the working side, is generally more elongated and with

(1) Universidade Federal da Bahia - UFBA, Salvador, BA, Brasil.

(2) Instituto de Ciências da Saúde da Universidade Federal da Bahia - UFBA, Salvador, BA, Brasil.

(3) União Metropolitana de Educação e Cultura, Salvador, BA, Brasil.

Conflict of interest: non-existent

reduced functional tonus, which can be a visually discernible muscle or even bone asymmetry[2,3].

The assessment of functional asymmetry of the craniofacial complex usually involves the jaw movement pattern and the activity of masticatory muscles[2]. The pattern of muscle pairs contraction can be investigated using electromyography of surface (EMG) - objective examination, capable to record the action potentials that occur by means of voluntary muscle activation or response to stimulation[5].

In the Speech Therapy area, the use of electromyography of surface are recent and aim to aid in the diagnosis of oral motor disorders, changes in swallowing, chewing and speech[6].

The masticatory pattern, as well as the electrical activity of masseter and temporalis masticatory muscles has been approached in the literature[7-10]. However, studies with children aged between 7 and 12 years are rare, especially with regard to the association between usual chewing and muscular electrical activity.

Thus, the analysis of the correlation between electromyographic activity of the masseter and temporalis muscles (during voluntary isometric contraction) and the preferred chewing side in children contributes to a better understanding of neuromuscular functioning of the craniofacial complex, for the functional differential diagnosis, and mainly to the therapeutic referring related to the balance of the stomatognathic system.

The aim of this study was to investigate the relationship of the rather side of masticatory with the electrical activity of the masseter and temporalis muscles.

METHODS

The study was approved by the Ethics Committee in Research of the College of Odontology of Federal University of Bahia (UFBa) by Opinion Number 17/10.

This is a cross-sectional descriptive and analytical study. The study was developed with 115 children, of both genders, aged 7-12 years, enrolled in regular public schools in São Francisco do Conde, Bahia. The guardians signed, agreeing to the "Terms of Free and Clear Consent".

Children with histories of facial trauma, head and neck surgery, clinical diagnosis of neurological disorders, craniofacial malformations, signs and symptoms of temporomandibular disorders (TMD) were excluded from the study.

To identify the signs and symptoms of TMD, was used as instrument the Anamnesic Index Simplified DMF11 and RDC protocol - Research Diagnostic Criteria - Criteria for Diagnosis in research [12].

The acquisition of the electrical activity of the masseter and temporalis masticatory muscles was recorded during 5 seconds of maximum voluntary isometric contraction in maximal intercuspal position through MIOTEC equipment with software MIOTOOL 400 4-channel filter of 500 Hz Low Pass and High Pass of 20 Hz.

For the exam, was made a prior to cleansing the skin of the students with 70% alcohol, in order to reduce the impedance. The procedure also facilitates the adhesion and uptake of electric potentials from muscle contraction.

The electrodes were placed in the most massive region of the anterior temporalis and masseter muscles by palpation in these regions during voluntary isometric contraction in maximal intercuspal position. The individual was kept sitting with open eyes, in a vertical backrest chair, with the head lined as the Frankfurt Horizontal Plane, keeping upper body relaxed on the lower limbs and feet flat on the floor, on a rug rubber.

The children were instructed to clench tightly the teeth for 5 seconds, contracting the masticatory muscles bilaterally and simultaneously. This procedure was performed 3 times with intervals of 30 seconds.

Then underwent occlusal evaluation, conducted by an orthodontist, based on the DAI - Dental Aesthetic Index[13], and also of the mastication record procedures, based on the adapted protocol MBGR[14] through a Sony digital camera 12x mp, with french bread used as food.

Before the start of mastication, the children were instructed to remain seated and looking ahead. They were handed with a piece of bread that could enable them biting and taking a piece. The request was: "You will chew and swallow the bread as you normally eat at home".

For analysis of electromyographic data, we adopted the average of the second and third records of the amplitude of the signal provided by the software in Root Mean Square (RMS). The first record was disregarded for analysis, once used as an understanding of the guidance provided before the exam test. The EMG data were normalized, taking as parameter to calculate the proportions of the maximum amplitude average (peak) obtained during the records.

Mastication was classified as unilateral preferential when observed a frequency of more than 60% of the cycles performed in a single side; bilateral when the cycles were run of 50 to 60 % of a side[4]. In relation of this latter mastication type, was considered alternating bilateral chewing when there

was presence of lateral and vertical movement of the mandible and simultaneous bilateral chewing when a predominance of vertical movements[15].

The collected data were properly analyzed using SPSS statistical software 17.0. The paired T' Student's test was adopted to verify the difference of normalized EMG averages (%) between the masseter and temporalid muscles pairs of left and right sides of the face. To verify the relationship between the type of occlusion and electrical activity of the muscles studied, as well as the electrical activity and masticatory pattern, the ANOVA test was used and the association between the variables "type of Occlusion" and "masticatory pattern" was analyzed using the Chi-square test. In all tests was considered $p < 0.05$ for statistical significance.

RESULTS

After examination of the masticatory preference side, we observed that of the total of 115 children, 76 (65.5%) had a preferred side during mastication, whereas 44 (38.3%) children showed preference masticatory to the right side and 32 (27.8%) preferred left chewing. Of the individuals without a preferential side, there was 23.5% (n = 27) alternating with bilateral chewing and 10.4% (n = 12) with simultaneous bilateral chewing.

According to the masticatory preference observed, the children were divided into four groups: Left Preferred Chewing Group (LPCG) Right Preferred Chewing Group (RPCG), Bilateral Simultaneous Chewing Group (BSCG) and Bilateral Alternating Chewing Group (BACG). The demographic data on gender, age and occlusion are described in Table 1.

Table 1 - Socialdemographic data of children distributed between the groups (N=115)

	LPCG (n=32)		RPCG (n=44)		BSCG (n=12)		BACG (n=27)	
GENDER	n	(%)	n	(%)	n	(%)	n	(%)
MALE	16	(50)	22	(50)	6	(50)	16	(59)
FEMALE	16	(50)	22	(50)	6	(50)	11	(41)
AGE (expressed in years)								
7-8	8	(25)	15	(34)	3	(25)	10	(37)
9-10	13	(41)	20	(45)	4	(33)	13	(48)
11-12	11	(34)	9	(21)	5	(42)	4	(15)
OCCLUSION								
CLASS I	20	(62)	28	(63)	7	(58)	16	(59)
CLASS II	10	(31)	13	(30)	4	(33)	10	(37)
CLASS III	2	(6)	3	(7)	1	(8)	1	(4)

LPCG - Left Preferred Chewing Group
RPCG - Right Preferred Chewing Group
BSCG - Bilateral Simultaneous Chewing
GMBA - Bilateral Alternating Chewing Group

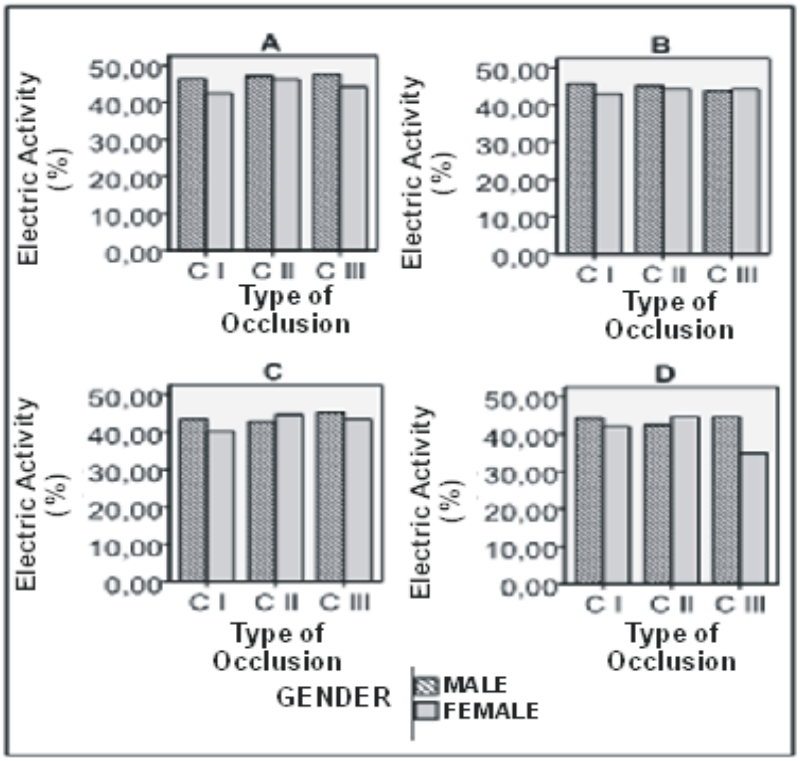
According to each chewing group, comparisons between the electrical activity of the right and left masseter and right and left temporal muscles were performed. From this analysis it was found that the levels of electrical activity of the muscles of the left side showed no statistically significant differences when compared with the average of its peers on the right side in all groups, $p < 0.05$ (Table 2).

Table 2 – Eletromyographic activity normalized (%) of the right and left masseter and temporalis muscles. (N=115)

MUSCLES	LPCG (n=32)	RPCG (n=44)	BSCG (n=12)	BACG (n=27)
RT	46,04 (9,32)	44,75 (5,69)	45,69 (8,31)	46,02 (3,41)
LT	44,44 (5,66)	44,97 (6,64)	44,13 (4,81)	44,53 (4,05)
p	0,251	0,791	0,430	0,136
RM	40,95(7,24)	44,21 (5,55)	43,57 (4,41)	42,26 (8,58)
LM	42,19 (7,72)	45,77 (5,06)	41,54 (4,83)	41,84 (6,86)
p	0,295	0,063	0,066	0,704

The eletromyographic activity is shown in average (standard deviation).
The determination of the statistical difference between the electric activity of the right and left sides of temporalis and masseter muscles was performed by T Student Test Paired. It was considerate significant p<0,05.
RM - Right Masseter LM - Left Masseter
RT - Right Temporalis LT - Left Temporalis
LPCG - Left Preferred Chewing Group
RPCG - Right Preferred Chewing Group
BSCG - Bilateral Simultaneously Chewing Group
BACG - Bilateral Alternating Chewing Group

No statistically significant relationship ($p < 0.05$) between the electrical activity of the muscles studied and the type of occlusion was found in the sample studied. Records the electrical activity of masseter and temporal muscles, according to the occlusion and gender, were shown as Figure 1.



A) Right Temporalis B) Left Temporalis
C) Right Masseter D) Left Masseter
CI – Class I of Angel CII – Class II of Angel
CIII – Class III of Angel

Figure 1 – Eletrical Activity (%) of reight and left temporalis and masseter muscles according to gender and type of occlusion.

When analyzed the chewing pattern and occlusion type, for the studied sample, there was no relationship between the variables (Table 3).

The analysis of the relationship between the electrical activity of muscles and chewing pattern surveyed also showed no statistical significance, $p < 0.05$ (Table 4).

Table 3 – Association between the masticatory pattern and type of occlusion (N=115)

Masticatory Pattern	Type of Occlusion			
	CLASS I	CLASS II	CLASS III	Total
BILATERAL ALTERNATING	16	10	1	27
RIGHT UNILATERAL PREFERRED	28	13	3	44
LEFT UNILATERAL PREFERRED	20	10	2	32
BILATERAL SIMULTANEOUSLY	7	4	1	12
Total	71	37	7	115
p				0,993

The association between the variables Masticatory Pattern and Type of Occlusion was checked through Chi-Square test, considering p<0,05 to statistical significance.

Table 4 – relationship of the masticatory pattern in the eletromyographic activity of masseter and temporalis muscles (n=115)

MUSCLES	LPC (n=32)	RPC (n=44)	BSC (n=12)	BAC (n=27)	p
RT	46,04 (9,32)	44,75 (5,69)	45,69 (8,31)	46,02 (3,41)	0,82
LT	44,44 (5,66)	44,97 (6,64)	44,13 (4,81)	44,53 (4,05)	0,96
RM	40,95(7,24)	44,21 (5,55)	43,57 (4,41)	42,26 (8,58)	0,20
LM	42,19 (7,72)	45,77 (5,06)	41,54 (4,83)	41,84 (6,86)	0,22

The eletromyographic activity is shown in normatized average (standard deviation)
The relationship between the masticatory pattern and the electrical activity of right and left masseter and temporalis muscles was performed by ANOVA test. It was considerate significant p<0,05
RM - Right Masseter LM - Left Masseter
LT - Left Temporalis RT - Right Temporalis
LPCG - Left Preferred Chewing Group
RPCG - Right Preferred Chewing Group
BSCG - Bilateral Simultaneously Chewing Group
BACG - Bilateral Alternating Chewing Group

DISCUSSION

Occlusion variable was not statistically different with the myoelectric activity of the masseter and temporal, bilaterally, as well as the chewing pattern. Thus, subjects were divided into four groups according to the preferred chewing side.

In this sample, the type of occlusion seems not to interfere as the chewing pattern. Findings agree with studies of Cavalcanti and Bianchini[16] and Duarte[17], who also found no significant correlation between occlusion and the preferred chewing side. However, is quoted in the literature the influence of occlusal factors in masticatory pattern mainly involving the unilateral occlusal pattern with changes and temporomandibular dysfunction[18,19].

When analyzing the association between the results of occlusion with electrical activity, also not statistically significant relationship was found. This result is similar to the study of Bevilaqua - Grossi et al.[20], which aimed to compare the electrical activity of the masticatory muscles during mastication in children with crossbite and children with normal occlusion. On the other hand, the research of Rodrigues, Bérzin and Siqueira[21] found no significant difference in electromyographic activity in different types of occlusion with children aged between 7 and 9 years with posterior crossbite.

The characterization of the results regarding masticatory preference, showed that of 115 children, 76 (65.5%) had a preferred side during mastication, whereas 44 (38.3%) children showed preference to right masticatory and 32 (27,8%) to left preferred

chewing. These results support the findings of previous studies, which report a high occurrence of mastication performed preferably on one of the sides[17, 22].

Skeletal muscle is composed of several fibers together with the neuron comprises the terminal motor unit[23]. The value provided by the EMG is the sum of the action potentials of all the muscle fibers of the motor unit, which come together in activity, because they are innervated by the same motor neuron[23].

The motor unit is the functional unit investigated by EMG in this study and the electrical signal provided by electromyography, faced the type of habitual mastication.

It is believed that making prolonged use of chewing preferably by one of the right and left sides, the musculature of the side of work becomes stronger, whereas the balancing side, the muscles are more elongated and with reduced tonus, showing often visible muscle asymmetry[3]. Thus, also in a state of isometric contraction through maximal intercuspal, as in this study, it would be possible to observe such features.

However, when analyzing the results, the likely physiological changes of masticatory muscles influenced by the pattern of chewing function were not observed on electromyographic signal amplitude. That means that the average of the electrical activity of the muscles of the left side showed no statistically significant differences when compared with the average of its peers on the right side in all groups studied, showing no relationship with the chewing pattern.

These results corroborate studies of Trawitzki et al.[24] and Alarcon et al.[25] that when analyzing the EMG activity of the temporal and masseter muscles in children with posterior crossbite, did not find significant differences in EMG activity of the masseter and temporalis muscles between crossed and uncrossed sides during mastication.

The research of Miranda, Vieira and Bommarito[26] and Vianna-Lara et al.[27] in order to examine the electromyographic activity of the masseter muscle in different facial types during rest and chewing, also found no statistically significant difference in the relationship.

Differing from the present study, the analysis of Faria et al.[10] with objective of compare the electromyographic activity of masticatory muscles in children aged 6 to 12 years with anterior open bite, compared to the control group, found significantly higher EMG activity in this last group. Similar to the study of Ferla, Silva and Corrêa[28], in which the pattern of electrical activity (during usual and maximal intercuspal chewing) of the anterior temporal and masseter muscles in children aged between 8 and 12 years old, with mouth breathing, proved to be lower than in nose breathers children, but statistically significant only in the left temporal muscle.

As previously shown, many studies[1,20,21,26,28] use electromyography as a tool for analysis of electrical activity of the masticatory muscles with different objectives. However, in the consulted literature no studies that assessed the relationship between the electrical activity of the masticatory muscles in isometric contraction and chewing pattern were found.

The results achieved in this study are consistent with the concept that electromyography effort evaluates the ability of the muscles to recruit as many motor units during maximal voluntary contraction. However, it is not possible to make a direct link between electromyographic findings and muscle strength, since muscle forces can be calculated directly through invasive procedures[23, 29].

The impracticality of this relationship due to possible variations in muscle strength due to changes in motor drive and speed of contraction without changing the amplitude of the eletromyographic signal [30,31]. This amplitude in turn, can be modulated by changes in the shape and speed of propagation of action potentials, without a concomitant change in the muscular strength[32,33].

This neuromuscular fatigue, for example, is described in the literature as a factor that induces a decrease in the speed of conduction of the potential action, an increase in loss of strength and synchronization can be compensated by recruitment of additional motor units [23,31,34,35]. These phenomena may induce an increase in the amplitude of the signal while the strength remains constant[36].

Although studies[29,37,38] try to find solutions featuring new methodological developments for this limitation, it is not yet possible to make a direct relationship between electromyographic findings and muscle strength.

CONCLUSION

From the results obtained, there was no relationship between habitual chewing pattern and the electrical activity of muscles, masseter and temporalis, according to the methodology adopted.

RESUMO

Objetivo: verificar a relação do lado de preferência mastigatória com a atividade elétrica dos músculos masseter e temporal. **Métodos:** a amostra foi composta por 115 crianças com idades entre 7 e 12 anos. A aquisição da atividade elétrica dos músculos mastigatórios foi registrada durante 5 segundos de contração isométrica voluntária em posição de máxima intercuspidação. As crianças foram distribuídas em quatro grupos de acordo com a preferência mastigatória observada: Mastigação Preferencial Direita, Esquerda, Bilateral Alternada e Bilateral Simultânea. Os dados eletromiográficos foram analisados através do software SPSS 17.0, e para a determinação da diferença estatística entre a atividade elétrica do lado direito e esquerdo, dos músculos masseter e temporal foi realizada pelo teste *T-Student* Emparelhado ($p < 0,05$). **Resultados:** do total de 115 crianças, 76 (63,4%) apresentaram um lado preferencial durante a mastigação habitual, sendo que 44 (36,7%) crianças apresentaram preferência mastigatória direita e 32 (26,7%) mastigação preferencial esquerda. Dos indivíduos sem um lado preferencial, verificou-se 25,8% (n=31) com mastigação bilateral alternada e 10,8% (n=13) com mastigação bilateral simultânea. Após comparação entre a atividade elétrica do músculo masseter e temporal, direito e esquerdo, de acordo com o grupo mastigatório, foi verificado que as médias da atividade elétrica dos músculos do lado esquerdo não apresentaram diferenças estatísticas significantes quando comparados com as médias dos seus pares do lado direito. **Conclusão:** para a amostra estudada, não foi verificada relação entre o lado mastigatório habitual e a atividade elétrica dos músculos, masseter e temporal.

DESCRITORES: Mastigação; Criança; Estudantes; Eletromiografia; Músculos Mastigatórios

REFERENCES

1. Muñoz GC, Silva C,Misaki JK, Gomes ICD, Carvalho ARR. Análise dos potenciais elétricos do músculo masseter durante a mastigação de alimentos com rigidez variada. Rev CEFAC. 2004;6(2):127-34.

2. Bianchini EMG. Mastigação e ATM. "In": Marchesan IQ (org). Fundamentos em fonoaudiologia: aspectos clínicos da motricidade oral. Rio de Janeiro: Guanabara- Koogan; 2005. p. 46-57.

3. Gomes LS, Bianchini EMG. Caracterização da função mastigatória em crianças com dentição decídua e dentição mista proposta de protocolo de avaliação clínica da função mastigatória. Rev CEFAC. 2009;11(3):324-33.

4. Amaral DB. Mastigação unilateral x oclusão normal: um estudo sobre sua ocorrência em crianças de 4 a 5 anos. Rev CEFAC. 2000;2:23-30.

5. De Rossi M, Vitti M, De-Rossi A, Hallak JEC, Semprini M, Regalo SCH. Electromyographic evaluation in children having rapid maxillary expansion. Am J Orthod Dentofacial Orthop. 2009;136(3):355-60.

6. Tartaglia GM, Sforza C. Eletromiografia de superfície dos músculos mastigatórios: instrumentos, métodos, aplicações na prática clínica. "In": Felício CM, Trawitzki LVV (org). Interfaces da Medicina, Odontologia e Fonoaudiologia no Complexo Cervico-Craniofacial. Barueri, SP: Pró-Fono; 2009. p.51-76.

7. Pignataro Neto G, Bérzin F, Rontani RMP. Identificação do lado de preferência mastigatória através de exame eletromiográfico comparado ao visual. Rev Dental Press Ortodon Ortop Facial. 2004;9(4):77-85.

8. Rahal A, Goffi-Gomez MVS. Estudo eletromiográfico do músculo masseter durante o apertamento dentário e mastigação habitual em adultos com oclusão dentária normal. Rev Soc Bras Fonoaudiol. 2009;14(2):160-4.

9. Vianna-Lara MS, Caria PH, Toselo O, Lara F, Amorin MM. Electromyographic activity of masseter and temporal muscles with different facial types. Angle Orthod. 2009;79(3):515-20.

10. Faria TSC, Regalo SCH, Thomazinho A, Vitti M, Felício CM. Masticatory muscle activity in children with a skeletal or dentoalveolar open bite. European Journal of Orthodontics. 2010;32:453-8.

11. Fonsêca DM, Bonfante G, Valle AL, Freitas SF. Diagnóstico pela anamnese da disfunção craniomandibular. RGO.1994;42(1):23-8.

12. Dworkin SF, Leresche L. Research diagnostic criteria for temporomandibular disorders: review, criteria, examinations and specifications, critique. J. Craniomandib Disord. 1992;6(4):301-55.

13. Cons NC, Jenny J, Kohout FL. DAi: The Dental Aesthetic Index. Iowa: University of Iowa, 1986.

14. Genaro KF, Berretin-Felix G, Rehder MIBC, Marchesan IQ .Avaliação miofuncional orofacial – protocolo MBGR. Rev CEFAC. 2009;11(2):237-55.
15. Felício CM, Ferreira CLP. Protocol of orofacialmyofunctional evaluation with scores. Int J Pediatr Otorhinolaryngol. 2008;72(3):367-75.
16. Cavalcanti RVA, Bianchini EMG. Verificação e análise morfofuncional das características da mastigação em usuários de prótese dentária removível. Rev CEFAC. 2008;10(4):490-502.
17. Duarte LIM. Relação entre maloclusão e mastigação. Rev Soc Bras Fonoaudiol. 2001;6(1):46-51.
18. Mazzetto MO, Nascimento G, Gomes NMS. Estudo da prevalência das alterações das funções estomatognáticas em pacientes com disfunção temporomandibular. J Bras Fonoaudiol. 2002;3(11):140-7.
19. Maciel CTV, Barbosa MH, Toldo CA, Faza FCB, Chiappetta ALML. Disfunções orofaciais nos pacientes em tratamento ortodôntico. Rev CEFAC. 2006;8(4):456-66.
20. Bevilaqua-Grossi D, Chaves TC, Lima-Duarte K, Oliveira AS. Atividade eletromiográfica dos músculos masseter e temporal anterior de crianças com mordida cruzada posterior unilateral (MCPU). Rev Bras Fisioter. 2005;9(3):257-63.
21. Rodrigues AMM,Bérzin F, Siqueira VCV. Análise eletromiográfica dos músculos masseter e temporal na correção da mordida cruzada posterior. R Dental Press Ortodon Ortop Facial. 2006;11(3):55-62.
22. Sproesser JG. Características das relações interoclusais em indivíduos com mastigação realizada preferencialmente sobre um dos lados e sintomas de disfunção temporomandibular. JBA. 2002;2(5):26-31.
23. Staudenmann D, Roeleveld K, Stegeman DF, Dieën JH. Methodological aspects of SEMG recordings for force estimation – A tutorial and review. Journal of Electromyography and Kinesiology 2010;20:375-87.
24. Trawitzki LVV, Felício CM, Puppin-Rontani RM, Matsumoto MAN, Vitti M. Mastigação e atividade eletromiográfica em crianças com mordida cruzada posterior. Rev CEFAC. 2009;11(3):334-40.

Received on: July 02, 2013
Accepted on: January 03, 2014

Mailing address:
Silvia Benevides
Av. Reitor Miguel Calmon, s/n, Vale do Canela
Departamento de Fonoaudiologia
Instituto de Ciências da Saúde
Universidade Federal da Bahia
Salvador – BA – Brasil
CEP: 40110-902
E-mail: silviabenevides@uol.com.br

25. Alarcón JA, Martín C, Palma JC. Effect of unilateral posteriorcrossbite on the electromyographic activity of human masticatory muscles. Am J Orthod Dentofacial Orthop. 2000;118(3):328-34.
26. Miranda ALR, Vieira MM,Bommarito S. Avaliação da atividade eletromiográfica do músculo masseter em diferentes tipos faciais. Revista Odonto. 2009;17(33):17-25.
27. Vianna-Lara MS, Caria PH, Toselo O, Lara F, Amorin MM. Electromyographic activity of masseter and temporal muscles with different facial types. Angle Orthod. 2009;79(3):515-20.
28. Ferla A, Silva AMT, Corrêa ECR. Atividade eletromiográfica dos músculos temporal anterior e masseter em crianças respiradoras bucais e em respiradoras nasais. Rev Bras Otorrinolaringol. 2008;74(4):588-95.
29. Loss J, Zaro M, Godolphim BH, Godolphim B, Michel C. Sugestão de método para correlacionar força muscular e eletromiografia. Movimento - Ano IV. 1998;8:33-40.
30. Carpentier A, Duchateau J, Hainaut K. Motor unit behaviour and contractile changesduring fatigue in the human first dorsal interosseus. J Physiol. 2001:903-12.
31. Enoka RM, Baudry S, Rudroff T, Farin D, Klass M, Duchateau J. Unraveling the neurophysiology of muscle fatigue. J Electromyogr Kinesiol. 2011;21(2):208-19.
32. Dimitrova NA, Dimitrov GV. Interpretation of EMG changes in fatigue: facts, pitfalls,and fallacies. J Electromyogr Kinesiol. 2003;13:13-36.
33. Keenan KG, Farina D, Maluf KS, Merletti R, Enoka RM. Influence of amplitude cancellation on the simulated surface electromyogram. J Appl Physiol. 2005;98:120-31.
34. Dideriksen JL, Farina D, Bækgaard M, Enoka RM. An integrative model of motor unitactivity during sustained submaximal contractions. J Appl Physiol. 2010;108:1550-62.
35. González-Izal M, Malanda A, Gorostiaga E, Izquierdo M. Electromyographic models to assess muscle fatigue. J Electromyogr Kinesiol. 2012;22(4):501-12.
36. Bouillard K, Guével A, Hug F. The electromyographic fatigue threshold is not a valid tool to assess muscle function.J Electromyogr Kinesiol. 2011;21(2):229-35.
37. Solomonow M, Baratta R, Zhou BH, Shoji H, D'Ambrosia RD. The EMG-force model of electrically stimulated muscles: dependence on control strategy and predominant fiber composition. IEEE Trans Biomed Eng. 1987;34(9):692-703.
38. Potvin JR, Brown SH. Less is more: high pass filtering, to remove up to 99% of the surface EMG signal power, improves EMG-based biceps brachii muscle force estimates. J Electromyogr Kinesiol. 2004;14(3):389-99.