https://doi.org/10.23925/2176-2724.2022v34i1e51813

ARTICLES

Variation of electrical activity between rest and maximum voluntary contraction of masseter muscles in adult men

Variação da atividade elétrica entre o repouso e a máxima contração voluntária dos músculos masseteres em homens adultos

Variación de la actividad eléctrica entre el descanso y la contracción voluntaria máxima de los músculos maseteros en hombres adultos

*Taylinne Santana Feitosa**
*Nathaly Santiago Silva**
*Gerlane Karla Bezerra Oliveira Nascimento**

Abstract

Introduction: Surface electromyography (EMGs) is an objective, painless, non-invasive and easily applied test used to assess the electrical activities of a particular muscle or muscle group during maximum voluntary contraction, rest and functional dynamics. **Objective:** Compare the variation in the electrical potential of the masseter muscles between rest and maximum voluntary contraction in individuals with different age groups. Method: The research was approved by the ethics committee and carried out at the Clínica Escola of the department of Speech, Language and Hearing Sciences at the Federal University of Sergipe, obeying ethical and biosafety rigors. The sample consisted of 26 adults without orofacial complaints, male with age from 26 to 42 years old, divided into Group 1 and Group 2, who signed a consent form agreeing to participate in the research. The volunteers underwent electromyographic evaluation of the masseter muscles during rest and maximum voluntary contraction. **Results:** There was

* Universidade Federal de Sergipe, Aracaju, SE, Brazil.

Authors' contributions:
TSF, NSS: Study design, article draft, and critical review.
GKBON: Methodology, data collection and orientation.

Correspondence email address: Taylinne Santana Feitosa - taylinne97@outlook.com
Received: 01/18/2021
Accepted: 02/17/2022

a decrease in the electrical activity of the masseter when comparing G1 to G2; however, there was no linearity of this decline when analyzing the universe studied. Therefore, it must be taken into account that aging is a particular physiological process of each individual, being influenced by multiple factors, intrinsic and extrinsic to the organism. It was also observed at rest, no individual had absolutely 0 in their electromyographic records, characterizing a baseline state of electrical activity to guarantee tone. **Conclusion:** It was found that volunteers aged 30 years or more showed a decline in myoelectric potentials and possibly an associated strength deficit.

Keywords: Masseter Muscle; Electromyography; Adult; Speech, Language and Hearing Sciences.

Resumo

Introdução: A eletromiografia de superfície (EMGs) é um exame objetivo, indolor, não invasivo e de fácil aplicação utilizado para avaliar as atividades elétricas de determinado músculo ou grupo muscular durante a máxima contração voluntária, repouso e dinâmica funcional. **Objetivo:** Comparar a variação do potencial elétrico dos músculos masseteres entre o repouso e máxima contração voluntária em indivíduos com faixas etárias diferentes. **Método:** A pesquisa foi aprovada em comitê de ética e executada na Clínica Escola do Departamento de Fonoaudiologia da Universidade Federal de Sergipe obedecendo aos rigores éticos e de biossegurança. A amostra foi composta por 26 adultos sem queixas orofaciais, sexo masculino e idade variando entre 26 e 42 anos, divididos em Grupo 1 e Grupo 2, os quais assinaram um termo de consentimento livre e esclarecido concordando com a participação na pesquisa. Os voluntários foram submetidos à avaliação eletromiográfica dos músculos masseteres durante o repouso e máxima contração voluntária. **Resultados:** Houve uma diminuição da atividade elétrica do masseter quando se comparou o G1 com o G2, porém não foi observada uma linearidade desse declínio ao analisar o universo estudado. Por isso, deve-se levar em consideração que o envelhecimento é um processo fisiológico particular de cada ser, sendo influenciado por múltiplos fatores intrínsecos e extrínsecos ao organismo. Observou-se, também, que no repouso nenhum indivíduo teve absolutamente 0 nos seus registros eletromiográficos, caracterizando um estado basal de atividade elétrica para garantia do tônus. **Conclusão:** Foi verificado que os voluntários com 30 anos ou mais apresentaram um declínio nos potenciais mioelétricos e, possivelmente, um déficit de força associado.

Palavras-chave: Músculo Masseter; Eletromiografia; Adulto; Fonoaudiologia.

Resumen

Introducción: Electromiografía de superficie (EMG) es una prueba objetiva, indolora, no invasiva y de fácil aplicación que se utiliza para evaluar actividades eléctricas de un músculo o grupo muscular en particular durante la contracción voluntaria máxima, el reposo y la dinámica funcional. **Objetivo:** Comparar la variación del potencial eléctrico de los maseteros entre reposo y contracción voluntaria máxima en individuos de diferentes grupos de edad. **Método:** La investigación fue aprobada por el comité de ética y realizada en la Clínica Escola del departamento de logopedia de la Universidad Federal de Sergipe obedeciendo rigores éticos y de bioseguridad. La muestra estuvo conformada por 26 adultos sin quejas orofaciales, varones y edades comprendidas entre 26 y 42 años dividido en Grupo 1 y Grupo 2, quienes firmaron formulario de consentimiento aceptando participar en la investigación. Los voluntarios se sometieron a evaluación electromiográfica de los músculos maseteros durante reposo y la máxima contracción voluntaria. **Resultados:** Hubo disminución en la actividad eléctrica del masetero cuando se comparó G1 con G2, sin embargo no hubo linealidad de esta disminución al analizar el universo estudiado. Por tanto, hay que tener en cuenta que el envejecimiento es proceso fisiológico particular de cada ser, siendo influenciado por múltiples factores intrínsecos y extrínsecos al organismo. También se observó que en reposo ningún individuo tenía absolutamente 0 en sus registros electromiográficos, caracterizando estado basal de actividad eléctrica para garantizar el tono. **Conclusión:** Se encontró que los voluntarios de 30 años o más mostraron una disminución en los potenciales mioeléctricos y posiblemente un déficit de fuerza asociado.

Palabras clave: Músculo Masetero; Electromiografía; Logopedia.

Introduction

Electromyography (EMG) is a method that analyzes the electrical activity of muscle fibers. This exam was built up over time by scholars who understood the biophysics of muscle contraction and the action of the nervous[1] system. The type of EMG will be defined according to the type of electrode used, which can be of two types: invasive when using a needle or metal wire, these can analyze the electrical potential of a specific motor unit, to investigate small or deep muscles; and surface when using active electrodes (adhered superficially to the skin, which reduce motion artifacts and noise) or passive (capable of detecting the signal without an amplifier and requires good preparation of the skin, in which the motion artifacts are amplified and analyzed as the real signal)[2].

Surface electromyography (EMGs) is an objective, painless, non-invasive, rapid, and easily applied test used to evaluate muscle activity during contraction, observing the physiological and pathological conditions of a muscle or muscle[3] group. The electrodes are placed longitudinally to the muscle fibers and glued on the site where the muscle has greater volume and mass, facilitating the capture of the response during the evaluated function. To assist in stabilizing the electrical signals, a reference electrode or ground is added at a point equidistant from the target area of assessment. Differential electromyographic amplifiers analyze only the potential difference between two electrodes by increasing it and rejecting the other signals[4.] Electromyographic signals are composed of amplitude, duration, and frequency. The electrical potentials captured by electrodes pass through a signal conditioner and produce a trace of amplitude in microvolts and time in milliseconds[5].

The electrical responses go through qualitative analysis represented by the visual recognition of the characteristics of the tracing so that any electrical dysfunction can be perceived, helping in the treatment of any alteration that may appear[6]. To obtain a good record of the electromyographic activity it is necessary to use a protocol for the execution of the exam, that is, the standardization of the patient's posture, positioning of the electrodes, sequence of movements, verbal instructions, and absence of electrical or electromagnetic interference.[7].

These results are of great value to help in the diagnosis and monitoring of muscle and functional rehabilitation. The disadvantages of its use are the difficulties that may appear when capturing this signal due to the anatomy and/or physiology of the muscle, such as the size of the fat layer at the site, poor positioning of the electrodes, and the subject being evaluated[8].

EMGs are used by various health specialties, especially speech therapy, which investigates the dynamics of the striated skeletal muscles of the head and neck regions involved in stomatognathic functions. Speech therapists use this examination as a complement to the clinical evaluation, in the diagnosis, helping to direct the intervention of orofacial myofunctional alterations, vocals, speech fluency, and currently oropharyngeal dysphagia. The exam provides information about the principles that govern muscle function, and thus helps in the diagnosis of various muscle pathologies, in kinesiological studies, and the prognosis of rehabilitation. Mastication is a stomatognathic function coordinated by the neuromuscular system, responsible for the accelerated and exact movements of the jaw and constant force modulations[9].

One of the components of masticatory function is the bite force (MF) performed by the jaw elevator muscles, which depends on the muscles, teeth, and nervous[10]system. Among these muscles are the masseter muscles, which act to close the mandible, requiring an adequate force for efficient chewing. In the[11.] resting position, the parameters found for the masseter and temporalis muscles are between 1.28 and 1.94 microvolts (µv)[12.] One study showed that the parameters for the right and left masseter during maximum intercuspation for 3 seconds are 34.8µv and 62.2µv, respectively. In the records of the masticatory cycles, this value is 15.2µv for the right masseter and 30.9µv for the left masseter[13].

With aging, there is a greater accumulation of adipose tissue and a decrease in muscle mass which is known as sarcopenia. This can have multifactorial causes, for instance, hormonal changes, loss of motor neurons, inadequate nutrition, and physical inactivity, and can harm the individual throughout his or her life. Because it is an alteration that involves the muscles, surface electromyography is one of the tests that will identify records of their activity at rest and in contraction[14]. Thus, the objective of this study was to compare the variation in the electrical potential of the masseter muscles during rest and maximum voluntary contraction in adult men of different ages.

Method

The research was approved by the Research Ethics Committee of the University Hospital of Aracaju, Federal University of Sergipe and all volunteers signed an Informed Consent Form.

This was a cross-sectional, analytical, observational study. Case series design

The volunteers were selected based on the inclusion criteria: male, adults, without orofacial complaints at the time of evaluation (verified through clinical evaluation of Orofacial Motricity performed by a Speech Therapy professional specialized in the area). The volunteers excluded from the sample were those with orofacial complaints, who used poorly fitted dental prostheses, lost more than three teeth or had ulcerative lesions in the oral cavity, used orthodontic or orthopedic appliances in the maxilla or mandible, with loss of oral sensitivity, dysphagic and volunteers with craniofacial syndromes or malformations, with temporomandibular dysfunction and who used medication such as more laxatives.

The universal sample was non-probabilistic, consisting of 35 subjects, 9 of whom were excluded after applying the exclusion criteria, and 26 were selected, with ages ranging from 26 to 42 years. The selected participants were submitted to surface electromyography to verify the performance of the masseter muscles. For this purpose, the volunteers were asked to position themselves in a comfortable sitting position on a chair with back support for the spine, without head support, knees and hips in 90º flexion, and feet fully supported on the floor or appropriate support according to the height of each individual.

Each participant underwent a facial inspection to locate the target muscles and prior cleaning of the skin covering them with gauze compress soaked in alcohol 70º (Figure 1) for allocation of the electrodes that captured the myoelectric responses. If there was hair in the region of adhesion of the electrodes, local trichotomy was performed with an individual and disposable razor blade with the consent of the volunteer.

Figure 1. illustration of the preparation for acquisition of myoelectric potentials of the masseter muscles: (left side) palpation of the masseter muscle; (right side) cleaning of the skin covering the masseter muscle.

The electrodes were positioned bilaterally on the face of the volunteer in a bipolar configuration in the region of greatest muscle mass and arranged longitudinally to the muscle fibers according to the following arrangement: Channel 1 - Right masseter muscle; Channel 2 - Left masseter muscle. To avoid interference, the reference electrode was positioned at a distant point from the recording site of the muscles being evaluated, and the olecranon of the ulna of the right arm of each volunteer (Figure 2).

Figure 2. Illustration of electrode placement: (Left side) Reference electrode positioned on the olecranon of the right arm ulna; (Right side) Electrode positioned on the masseter.

After orientation on the characteristics of the test, electromyographic potentials were recorded during muscle rest in habitual centric occlusion (for 60 seconds) and during maximum controlled voluntary contraction (lasting 5 seconds and repeated 3 times with rest intervals lasting 10 seconds between each contraction. The result of the arithmetic mean between the 3 contractions was considered for analysis), in which cotton swabs were placed bilaterally between the dental arches to acquire the normalization of the electromyographic signal and eliminate occlusal interferences (Figure 3).

Figure 3. Illustration of the maximum controlled voluntary contraction-use of the cotton swabs.

The electromyograph used was the MIOTOOL 200/400 - 4 channels (MIOTEC®) with Miograph 2.0 software, using a gain of 1000, 4 SDS500 sensors, Reference cable and calibrator. For the capture, and conduction of the electromyographic signal, disposable 3M® surface electrodes were used, consisting of a material composed of Ag/AgCl, immersed in conductive gel (Figure 4).

The myoelectric acquisitions were windowed via the selection of the periods of rest and maximum contraction from the graphs generated by the Myograph software and transformed into RMS (root mean square). After the exam, the individuals were divided into two groups according to their age, G1- individuals aged up to 30 years old, and G2- individuals aged 31 years old and older. To analyze these data we used quantitative and qualitative measures: mean, median, and standard deviation, as well as absolute and percentage frequencies. The data were entered and analyzed in a Microsoft Excel 2000 spreadsheet. They were stored in a portable microcomputer used exclusively for the research, which was under the responsibility of this study's supervisor.

Figure 4. Electromyograph, sensors, cables, electrodes, and microcomputer used for the acquisition of the masseter electromyographic exam.

Results

The data collected were analyzed in a way that shows the masseter muscle resting and its maximum voluntary contraction, emphasizing that even at rest there is a small contraction action that corresponds to the basal tonus. The presentation of the results in percentage (%) is in Tables 1 and 2.

Table 1. Percentage values of the electric potentials of the right and left masseters at rest and maximum voluntary contraction in the individuals in group 1.

VOLUNTEER	AGE	EMG REST		EMG CONTRACTION	
		RIGHT	LEFT	RIGHT	LEFT
3	26	0.73	1.15	70.16	65.93
4	26	0.71	0.96	39.21	45.39
15	26	2.74	2.14	177.8	109.3
5	27	2.22	1.79	48.38	28.42
7	27	1.96	1.66	70.51	43.59
30	27	3.66	2.59	170.52	105.95
8	28	1.89	2.69	66.86	61.73
6	29	1.76	1.35	77.37	79.62
18	29	2.87	3.83	106.56	119.51
10	30	3.29	3.43	134.12	88.43
25	30	0.78	1	93.88	32.32
27	30	1.41	1.07	50	61
MD	27.9	2	1.97	92.11	70.09
MEDIAN	27.5	5.55	2.64	118.69	83.84
SD	1.6	0.99	0.97	46.47	30.65

Legend: MD: mean SD: standard deviation

Table 2. Percentage values of the electric potentials of the right and left masseters at rest and maximum voluntary contraction in the individuals in group 2.

VOLUNTEER	AGE	EMG REST		EMG CONTRACTION	
		RIGHT	LEFT	RIGHT	LEFT
2	32	1.31	3.37	26.27	47.42
11	32	1.94	1.9	94.43	24.43
13	32	2.06	0.97	50.18	24.82
19	32	2.15	1.4	91.82	55.37
21	32	2.66	1.03	215.47	61.94
23	32	0.84	1.08	17.23	25.9
24	32	0.57	0.41	70.95	65.37
28	32	2.71	2.13	37.7	48.96
29	32	1.48	1.11	65.74	59.88
14	33	2.61	2.83	22.61	99.58
16	33	8.96	6.98	76.98	96.47
20	33	1.88	2.94	53.5	49.5
22	34	6.29	1.78	4.65	7.47
MD	32.3	2.72	2.14	63.65	51.31
MEDIAN	32	0.57	0.41	70.95	65.37
SD	0.65	2.33	1.69	53.77	27.05

Legend: MD: mean SD: standard deviation

In this way, to know how much potential was necessary for contraction, that is, muscle gain, we subtracted the value at maximum voluntary contraction and its rest. The values of gain obtained are illustrated in Tables 3 and 4.

Table 3. Electrical gain in percentage of the right and left masseters in the individuals in group 1.

VOLUNTEERS		DIFFERENCE	
	AGE	LAW	LEFT
3	26	69.43	64.78
4	26	38.5	44.43
15	26	175.06	107.16
5	27	46.16	26.63
7	27	68.55	41.93
30	27	166.86	103.36
8	28	64.97	59.04
6	29	75.61	78.27
18	29	103.69	115.68
10	30	130.83	85
25	30	93.1	31.32
27	30	48.59	59.93
MD	27.9	90.11	68.12
MEDIANA	27.5	115.91	81.2
DP	1.6	45.73	29.99

Legend: MD: mean SD: standard deviation

Table 4. electrical gain in percent of the right and left masseters in the individuals in group 2.

VOLUNTEERS		DIFFERENCE	
	AGE	LAW	LEFT
2	32	24.96	44.05
11	32	92.49	22.53
13	32	48.12	23.85
19	32	89.67	53.97
21	32	212.81	60.91
23	32	16.39	24.82
24	32	70.38	64.96
28	32	34.99	46.83
29	32	64.26	58.77
14	33	20	96.75
16	33	68.02	89.49
20	33	51.62	46.56
22	34	-1.64	5.69
MD	32.3	60.928	49.167
MEDIANA	32	70.38	64.96
DP	0.65	53.87	26.24

Legend: MD: mean SD: standard deviation

Based on the results obtained, a mean comparison of the right and left masseters was made between the two groups, noting greater electrical activity of the muscles in group 1, as illustrated in Figure 5. We obtained a difference of 29.185 and 18.961 in the mean of the right and left masseters, respectively, when comparing the groups. Thus, we observed that there was a decrease in the percentage of variation of electrical activity between rest and maximum voluntary contraction of the masseter with age.

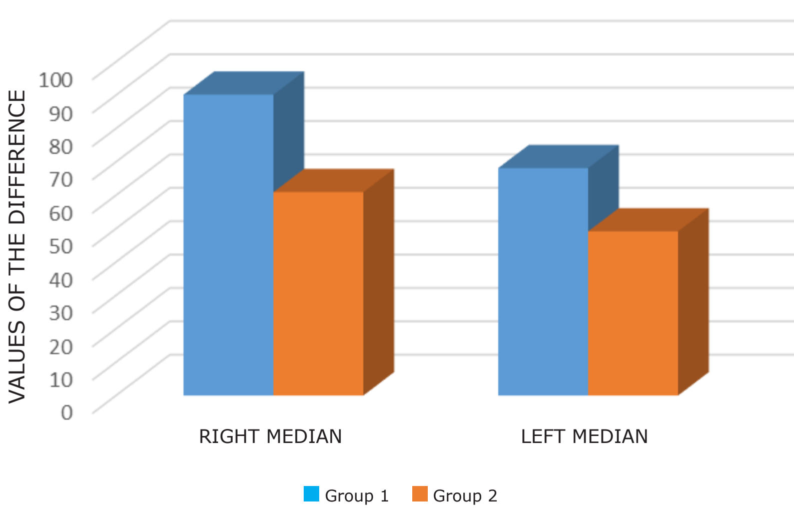

Figure 5. Percentage values of the comparison of the differences between the masseter means in the two groups.

In the present study, some statistical measures were used to organize the data collected to direct their study. Among them, the mean was used to give an initial notion about the performance of the groups in terms of rest, maximum voluntary contraction, and muscle gain of the masseters, thus observing what the average muscular electrical activity of each group was. It was noticed a high discrepancy between the values found, so the standard deviation was high; therefore, the median was used to better reflect the characteristics of the groups, because it corresponds to the value that is in the middle of the distribution.

Discussion

Aging is a natural, progressive, and biological process. Thus, one should not always associate this term with disease or inactivity[15], because it is different in each individual and depends on the lifestyle and biological characteristics of each being[16]. In the biological aspects we must take into consideration that a cellular, molecular, tissue, and organic[17] alteration occurs**.**

The complete maturation of the muscular system in humans is reached between 20 and 30 years of age. After the age of 30, muscle density begins to decline and there is a gradual and selective decrease in skeletal fibers that give way to adipose tissue and collagen[18]. Some researchers report that the peak of muscle strength is reached at the age of 30 and is maintained until the age of 50. It decreases by 20 to 40 percent between ages 70 and 80, and after age 90 it drops by 50[14] percent. Based on this information, the groups in this study were divided as follows: G1- individuals aged up to 30 years and G2- aged 31 years and older.

Sarcopenia is the term used to describe the loss of muscle mass and strength associated with increasing age[14]. In this process, there is a gradual decline in muscle tissue and the number and size of fibers. Based on these aspects, the two groups studied suffered a reduction in the electrical potential of the masseter muscle. The striated skeletal muscle contains two main types of fiber: I or red, slow twitch, resistant to fatigue and with high activity of oxidative enzymes; and II or white, fast-witch, fatigue quickly and have low oxidative capacity. According to research, the size and number of type II muscle fibers decrease much more than type I with aging[19].

Researchers made a histochemical and quantitative analysis of the mandibular elevator muscles, in which they noticed a predominance of type I fibers in the masseter and medial pterygoid showing a greater concentration in the superficial bundle of the masseter and in the anterior part of the medial pterygoid. On the other hand, the posterior parts of the masseter and pterygoid we observed a greater presence of type IIB[20]. The human body depends on a chemical and electrical integrity of the nerves for the memorization of functions through neuron interaction in the brain. The Motor Unit (MU) is the basic component of motor control and is composed of an anterior horn cell, an axon, muscle junctions, and the fibers it innervates. The nerve impulses conducted to the muscle fibers cause them to depolarize, producing an electrical activity that manifests itself as a motor unit action potential (MUAP) analyzed by EMG. For the muscle to exert force this potential must propagate along the sarcolemma. When it reaches the end motor plate it will stimulate the release of acetylcholine neurotransmitter that will cause the opening of sodium channels, causing depolarization of the membrane and initiation of the action potential, being conducted along with the muscle fiber of the sarcolemma in all directions and down the T tubules, resulting in complete activation of the muscle[8] fiber.

The strength of the masticatory muscles defines the amount of load to grind the food and this can be measured through the use of specific[21] equipment. Among them is the surface electromyography (EMGs), which can be used to analyze the function of these muscles, identifying the variations in potentials during contractions**,** helping in the diagnosis and therapeutic proposal of stomatognathic functions and orofacial[3,10] motor disorders. For these reasons, EMGs were used in this research to obtain answers about muscle strength and then compare the results.

The relationship of electromyography recordings, especially its amplitude with muscle force production, has been studied by several researchers who try to show that EMG is one of the ways to obtain force[22] measurements. Some authors believe that several obstacles may appear in this relationship because it depends on physiological, anatomical, and technical factors that are different in each individual. Thus, even if the greater the force, the greater the amplitude of the signal, it only shows the quality of these areas, but it is not possible to observe a quantitative[23] relationship. Other studies point out that the direct relationship of these variants will depend on the muscles studied[24], since in small muscles it can be linear, while in larger muscles it is non-linear[25,26]. EMGs capture the electrical activity of the site where the electrode is located, so the action potential of the motor unit captured will always be less than the PAUM active in the muscle[23]. Thus, in smaller muscles, it is easier to achieve a higher electrical[27] signal.

Based on the aforementioned studies, as the masticatory muscles are considered small, especially the masseter, the linearity of the relationship between electrical activity and strength of the muscle studied can be applied. In this research, the participants were divided into two groups with ages before and after 30 years old, respectively. We noticed a slight decline in the power of the right and left masseters in G1 individuals compared to G2, assuming the onset of muscle mass and strength loss after 30 years of age. Aging is different in each individual, as mentioned above. For this reason, when the research participants were placed in increasing order of age, no decline was observed, but the same was verified when comparing the two groups studied.

Studies show that in normal individuals without any complaints of any changes in the structures involved, there is the presence of electrical muscle activity even if the jaw is at rest[2], taking into account that this serves to maintain muscle tone. This finding was confirmed in this study, since the analysis of EMG records showed that none of the subjects had exactly zero at rest. For this reason, these values must be taken into consideration when the maximum contraction is evaluated, with the need to subtract the value of contraction by its rest to know the gain in muscle electrical activity. Other authors state that the muscle at rest has no electrical activity or contraction, but the present study proves otherwise[12].

Conclusion

The present study compared the electrical activities of the masseter muscles of adult men, at rest and maximum voluntary contraction, using surface electromyography. It was verified that the volunteers aged 30 years or more presented a decline in myoelectric potentials and, possibly, an associated strength deficit. This fact may have repercussions on the functionality of the Stomatognathic System (SS) and calls attention to the need to carry out studies with a larger number of participants, focusing on the functional characterization of the SS from 30 years of age onward.

Bibliographical references

1. Silva RCd. Eletromiografia de Superfície: função neuromuscular e reprodutibilidade do método. Uma revisão [Monografia]. Porto Alegre: Universidade Federal do Rio Grande do Sul-UFRGS; 2010.

2. Takahashi LSO. Análise da relação entre eletromiografia e força de músculo quadríceps em exercícios resistidos [Dissertação]. São Carlos: Interunidades em Bioengenharia-USP; 2006.

3. Rahal A, Pierotti S. Eletromiografia e cefalometria na Fonoaudiologia. In: Ferreira LP, Befi-lopes DM, Limongi SCO. (Org.) Tratado de Fonoaudiologia. São Paulo: Roca, 2004; p. 237-53.

4. Dawalibi NW, Anacleto GMC, Witter C, Goulart RMM, Aquino RdCd. Envelhecimento e qualidade de vida: análise da produção científica da SciELO. Estud. psicol. 2013; 30(3): 393-403. Doi: 10.1590/S0103-166X2013000300009

5. Quirch JS Interpretación de registros eletromiograficos en relación com la oclusión. Rev.Assoc.Odontol. 1965; 53(9): 307-12

6. Lund JP; Widmer CG. Evaluation of the use of surface electromyography in the diagnosis, documentation, and treatment of dental patients. J Craniomandib Disord. 1989; 3(3): 125-37.

7. Fridlund AJ; Cacioppo JT. Guidelines for human electromyographic research. Psychophysiology.1986; 23(5): 567-89. Doi: https://doi.org/10.1111/j.1469-8986.1986.tb00676.x

8. Sampaio CRA. Avaliação eletromiográfica dos músculos masseter e temporal anterior após o uso da placa de Hawley modificada em pacientes com DTM [Dissertação]. Recife: Universidade Federal de Pernambuco UFPE; 2003.

9. Karkazis HC, Kossioni AE. Surface EMG activity of the masseter muscle in denture wearers chewing of hard and soft food. J Oral Rehabil .1998; 25(1): 8-14. DOI: 10.1046/j.1365-2842.1998.00193.x

10. Nascimento GKBO, Lima Lmd, Rodrigues CBdS, Cunha RAd, Cunha Dad, Silva Hjd. Verificação da força de mordida e da atividade elétrica dos músculos masseteres durante a mastigação em laringectomizados totais. Rev. bras. odontol. 2011; 68 (2): 175-9. Doi: : http://dx.doi.org/10.18363/rbo.v68n2.p.175

11. Chaves JJC. Efeitos da eletroestimulação neuromuscular sobre a atividade elétrica e força do músculo bíceps braquial. [monografia]. Criciúma: Universidade do Extremo Sul Catarinense; 2011.

12. Oncins MC; Freire RMAdC; Marchesan IQ. Mastigação: análise pela eletromiografia e eletrognatografia. Seu uso na clínica fonoaudiológica. Distúrb. Comum. 2006; 18 (2): 155-65. Disponível em: https://revistas.pucsp.br/index.php/dic/article/view/11781

13. Silva HJ da et al. Uso de protocolo de normalização do sinal eletromiográfico na mastigação e as relações com a eletrognatografia. In: RAHAL, Adriana et al. Eletromiografia de Superfície na Terapia Miofuncional. São José dos Campos: Pulso Editorial, 2014. p. 88.

14. Pícoli TdS; Figueiredo LLd; Patrizzi LJ. Sarcopenia e envelhecimento. Fisioter Mov. 2011; 24(3): 455-62. Doi: 10.1590/S0103-51502011000300010

15. Loeb GE; Gans C. Electromyography for experimentalists. Chicago: University of Chicago Press, 1986.

16. Oncins MC; Vieira MM; Bommarito S. Eletromiografia dos músculos mastigatórios: análise em valor original e rms. Rev. CEFAC. 2014; 16(4): 1215-21. Doi: https://doi.org/10.1590/1982-021620146913

17. Fechine BRA; Trompieri N. O processo de envelhecimento: as principais alterações que acontecem com o idoso com o passar dos anos. InterSciencePlace. 2012; 1: 106-32. D.O.I: http://dx.doi.org/10.6020/1679-9844/2007

18. Esquenazi D; Silva SBd; Guimarães MA. Aspectos fisiopatológicos do envelhecimento humano e quedas em idosos. Revista HUPE. 2014; 13(2): 11-20. Doi: 10.12957/rhupe.2014.10124

19. Palinkas M. Influência da idade e do gênero na força de mordida molar máxima e espessura dos músculos mastigatórios [Dissertação]. Ribeirão Preto: Faculdade de Odontologia de Ribeirão Preto-USP 2010.

20. Eriksson Po; Thornell L-e. Histochemical and morphological musclefibre characteristics of the human masseter, the medial pterygoid and the temporal muscles. Arch Oral Biol. 1983; 28(9): 781-95. Doi: 10.1016/0003-9969(83)90034-1.

21. Kiliaridis S, Kjellberg H, Wenneberg B, Engström C. The relationship between maximal bite force, bite force endurance, and facial morphology during growth. A crosssectional study. Acta Odontol Scand. 1993; 51(5): 323-31. Doi: 10.3109/00016359309040583.

22. Zhou P, Rymer WZ. Factors governing the form of the relation between muscle force and the EMG: a simulation study. Neurophysiol. 2004; 92(5): 2878–86. Doi: 10.1152/jn.00367.2004

23. DeLuca CJ. The Use of Surface Electromyography in Biomechanics. J. App Biomech. 1997; 13: 135-63. DOI: https://doi.org/10.1123/jab.13.2.135

24. Lawrence H. DeLuca C. Myoelectric signal versus force relationship in different human muscles. Amer. Physiolo. Soci. 1983; 1653-9. Doi: 10.1152/jappl.1983.54.6.1653

25. Perry J, Bekey GA. EMG-force relationships in skeletal muscle. 1981; 7(1):1-22.

26. Solomonow M, Baten C, Smit J, Baratta R, D'Ambrosia R Shoji H,. Electromyogram power spectra frequencies associated with motor unit recruitment strategies. J App Physiol. 1990; 68(3): 1177-85. Doi: 10.1152/jappl.1990.68.3.1177

27. Noda DKG; Marchetti PH; Vilela Junior GdB. Eletromiografia de Superfície em Estudos Relativos à Produção de Força. Rev CPAQV. 2014; 6(3): 1-25. Disponível em: http://www.cpaqv.org/revista/CPAQV/ojs-2.3.7/index.php?journal=CPAQV&page=article&op=view&path%5B%5D=55

28. Pavão RF. Avaliação eletromiográfica dos músculos da mastigação, da movimentação mandibular e do posicionamento condilar de pacientes desdentados totais com disfunção temporomandibular, antes e após a instalação de próteses totais com pistas deslizantes de Nóbilo [Tese]. Ribeirão Preto: Faculdade de Odontologia de Ribeirão Preto-USP; 2007.