RESEARCH ARTICLE

Evaluation of the electromyographic activity of masseter and temporalis muscles of women with rheumatoid arthritis

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Abstract
Aim: This study aimed to evaluate the electromyographic activity of the masseter and temporalis muscles of women with rheumatoid arthritis.
Methods: The sample comprised 28 women divided into two groups: 14 with rheumatoid arthritis [mean age: 52.2 ± standard deviation (SD): 3 years] and 14 without rheumatoid arthritis (mean age: 49.4 ± SD: 2.4 years). The women were paired by age and body mass index. The electromyographic activity of the masseter and temporalis muscles was analyzed in mandibular tasks: rest, right and left laterality, protrusion, maximal voluntary contraction with and without Parafilm M®, habitual and non-habitual chewing. The MANOVA (multivariate analysis of variance) was used to compare the means of the two independent groups, considering as independent variable side and diagnosis of rheumatoid arthritis, and age as the covariate. The Bonferroni correction was used for the post hoc comparisons (p <0.05).
Results: Rheumatoid arthritis group presented an increase in the normalized electromyographic activity of the masticatory muscles and lower mean values for the habitual and non-habitual chewing.
Conclusions: Women with rheumatoid arthritis showed functional alterations in the stomatognathic system, demonstrated through muscular hyperactivity and reduction of masticatory efficiency. HIPPOKRATIA 2018, 22(1): 3-9.

Keywords: Rheumatoid arthritis, electromyography, masticatory efficiency, masseter muscle, temporal muscle

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Introduction

Rheumatoid arthritis is an inflammatory, chronic, systemic, erosive, relapsing, autoimmune and non-suppurative rheumatic disease of the connective tissue that affects the synovial membrane, tendons, and joint surfaces[1]. It is considered extremely complex with multiple comorbidities[2] and can lead to deformity, disability, and even to premature death[3,4]. The evolution of the disease varies over the years, with periods of intense activity and remissions, with a progressive degeneration usually symmetrical of the joints[5] and functional impairment of the human organism[6].

The clinical evolution can be classified in progressive stages; where first, deformities can be observed, and subsequently, destructive alterations (cartilage, joint, and bone structure), evidenced by X-ray and nuclear medicine examinations. It affects approximately 0.15 to 1.7 % of the world population, mainly in the age group between 40 and 60 years, and women are more affected than men[7,8].

According to the American College of Rheumatology, 1.3 million Americans develop rheumatoid arthritis annually, and 75 % are women. Brazil is the country of the South American continent with the highest prevalence of rheumatoid arthritis, with about 1.8 million diseased people[9] while in the European countries it ranges from 0.4 to >2.5 cases per 1,000 adults[10].

In view of the high incidence of rheumatoid arthritis, it is important to evaluate whether the disease can lead to changes in the masticatory muscles function. In the area of dentistry, rheumatoid arthritis is of great importance because it affects the temporomandibular joint[11] and may cause alterations in muscle function, inflammation in the joint capsule, painful symptoms, and resorption of the head of the mandible[12].

The harmonious balance of the musculoskeletal system is fundamental to the well-being of humans, and functional alterations resulting from chronic degenerative diseases have been the subject of worldwide studies[13].

The primary hypothesis of the current study was that rheumatoid arthritis disease decreases chewing efficiency, which in turn can increase the electromyographic activity of masticatory muscles. Therefore, this study aimed to determine the electromyographic activity of the masseter and temporal muscles of women with rheumatoid arthritis. These results could help to guide future medical and dental treatments related to the stomatognathic system.

Materials and methods

This transverse observational study was approved in 2017 by the School of Dentistry of Ribeirão Preto of the University of São Paulo Ethics Committee (No 43010515.8.0000.5419), in compliance with the Resolution 466/12 of the National Health Committee.

We conducted this study in centers specialized in the treatment of chronic degenerative diseases, located in the cities of Ribeirao Preto, Bededouro, and Batatais in the State of São Paulo, Brazil in the year 2017.

Sample

A post hoc sample size calculation was conducted considering a level of α =0.05, a power of 83 % for the primary outcome electromyographic activity in right laterality [average of the right masseter muscle, women with rheumatoid arthritis group =0.28 (0.21) and healthy women without rheumatoid arthritis group =0.12 (0.08)], and effect size of 1.006. The minimum sample size obtained was 28 participants (14 for each group). Sample size calculation was performed with the G*Power software v 3.0.10 (Franz Faul, Kiel University, Kiel, Germany).

During this study we evaluated sixty-seven women with rheumatoid arthritis with normal occlusion (Angle's Class I), contact pattern in intercuspal position was tooth to two tooth occlusion, and presence of all permanent teeth (except third molars).

We excluded women with rheumatoid arthritis who reported on presentation bruxism in wakefulness (n: 5) and in sleep (n: 8), previous obstructive sleep apnea diagnosis (n: 6), mandibular tori (n: 3)[14], current or previous orthodontic treatment (n: 2), physical therapy (treatment of disease or injury by physical methods such as massage, heat treatment, and exercise) (n: 5)[15], physical changes (from infection, trauma, accident, intoxication) or mental illness (n: 6), neurological and psychiatric disorders (n: 4), and use of medications (muscular relaxant, anti-histamines, sedatives or central nervous system depressors) that could interfere with the electromyographic activity of the skeletal striated muscles[16] (n: 14).

After applying the exclusion criteria, 14 women with rheumatoid arthritis were enrolled and subsequently were matched subject-to-subject with 14 healthy women of similar age and body mass index (BMI) without rheumatoid arthritis. The total sample consisted of 28 women divided into two groups: women with rheumatoid arthritis [n: 14; mean age: 52.2 ± standard deviation (SD): 3 years; BMI: 31.11 ± 1.23 kg/m^2] and women without rheumatoid arthritis (n: 14; mean age: 49.4 ± SD: 2.4 years; BMI: 27.59 ± 1.13 kg/m^2). There were no significant differences between the two groups in terms of age (p =0.46) and BMI (p =0.09). Such matching is a convenient method for minimizing confounding in case-control studies as it balances the clinical characteristics of the two groups[17]. The interview and clinical evaluation with consecutive patients were performed by a single examiner, a trained dentist.

Women with rheumatoid arthritis had their diagnosis validated by rheumatologists, based on the clinical signs, symptoms, and laboratory and radiographic findings[13]. Women of the rheumatoid arthritis group presented sensitivity to digital palpation in the right and left preauricular region (research diagnostic criteria for temporomandibular disorders - RDC/TMD)[18], with a median disease duration of six years, and with an uncontrolled disease in the past year.

Electromyographic analysis

We used the Trigno electromyography equipment (Delsys Inc., Boston, MA, USA), wireless surface electrodes, and followed the SENIAN (Surface Electromyography for the Non-Invasive Assessment of Muscles) guideline[19]. We performed electromyographic recordings (µV) of the right masseter (RM), left masseter (LM), right temporal (RT), and left temporal (LT) muscles during mandibular tasks: rest (4 s), right and left laterality (10 s each) with canine guidance, protrusion (anterior guidance) and presenting the Christensen phenomenon (10 s), and dental clenching in maximum voluntary contraction with (4 s) and without inert material (4 s).

The inert material used for dental clenching in maximum voluntary contraction was composed of paraffin sheet (Parafilm M®, Pechiney Plastic Packaging, Batavia, IL, USA) which was folded (18 × 17 × 4 mm, weight 245 mg), and inserted between the occlusal faces of the first and second molars (right and left side)[20].

For the analysis of habitual chewing with hard food, peanuts were used, and for soft food, raisins without seeds were utilized. The food belonged to the same batch, and five grams of each type of food was used. The food was stored in a cool, ventilated area in individual plastic containers. Non-habitual chewing was performed by Parafilm M® chewing, placed on both sides of the dental arches.

Before the placement of the wireless surface electrodes, the skin surface was cleaned and sanitized with alcohol and, to ensure correct fixation of the electrodes, a specific maneuver of maximum voluntary contraction was performed, followed by palpation to locate the muscular belly[21].

For the electromyographic recordings, the research participants were in a quiet and calm environment. They remained seated in a comfortable chair that maintained an upright posture, with their soles resting on the ground and their palms resting on their thighs. Their heads were positioned so that the Frankfurt horizontal plane remained parallel to the ground[22].

For the dynamic evaluation of electromyographic activity in chewing, the function of the masticatory cycles was assessed using the values of the linear envelope integral of the masseter and temporalis muscles[16]. The values were obtained between intervals of five to ten seconds. The initial masticatory cycles were excluded because the first cycles present considerable variation in the pattern of mandibular movement[23].

Prior to the examination, participants were informed about the types of food to be chewed, emphasizing that they should not necessarily swallow them; and they had the option of discarding them in an appropriate container.

Statistical analysis

Following data collection, a normality test was applied, and normal data distribution was observed (Shapiro-Wilk test).

All electromyographic data were normalized by maximum voluntary isometric contraction with Parafilm M®. Values were recorded in Root Mean Square (RMS). The IBM SPSS Statistics for Windows, version 22.0 (IBM SPSS, IBM Corp., Armonk, NY, USA), was used for the statistical analysis.

The normalized electromyographic data were obtained through the descriptive analysis (average and standard deviation) for each variable. The values were compared using a MANOVA (multivariable analysis of variance) considering side and diagnoses as factors, and age as a covariate. The Bonferroni correction was adopted as post hoc analysis on pairwise comparisons ($p < 0.05$).

Results

Overall result

Considering MANOVA findings, our results showed a main effect for group [Pillai´s trace =0.68, F =4.86, p =0.001 (df =36)], side [Pillai´s trace =0.48, F =2.13, p =0.03 (df =36)], and no effect for age [Pillai´s trace =0.44, F =1.83, p =0.065 (df =36)]. In addition, we did not verify an interaction between group x side [Pillai´s trace =0.32, F =1.07, p =0.412 (df =36)]. However, the side effect was significant only for one variable: electromyography of temporalis muscles [F(1,51) =14.97, p =0.001] during right laterality. Considering such finding, we decided to describe the mean value from right and left sides of the variables included in this study.

Electromyographic variables

The normalized electromyographic data were described either separately and the mean values between sides, whereas the results showed a mean effect for side regarding electromyographic variables (Table 1).

Differences between sides were observed in both groups, during right laterality in which it was observed lower electromyographic activity for the left side in temporalis muscles (Table 1).

In addition, when considering the mean value between both sides (Table 1), the group main effect was observed during right laterality task for the temporal muscle [F(1,51) =14.97, p <0.0001]. On pairwise comparisons, for all muscles and tasks, higher electromyographic activity was observed for the woman of the rheumatoid arthritis group compared to the women of the non-rheumatoid arthritis group (Table 1).

Chewing variables

The normalized electromyographic data were described either separately and the mean values between sides, whereas the results showed a mean effect for side regarding chewing variables (Table 2).

No differences were observed between the sides in both groups (Table 2). In addition, when considering the mean value between both sides (Table 2), no difference was observed between the groups for masseter and temporalis muscles. On pairwise comparisons, for all muscles and chewing, decreased masticatory efficiency was observed in almost all conditions evaluated for the woman of the rheumatoid arthritis group compared to the women of the non-rheumatoid arthritis group (Table 2).

Discussion

The study of muscle function through the electromyographic examination of participants with chronic degenerative diseases is extremely important, because it shows changes in the neuromuscular pattern[24].

In the present study, it was observed that the pattern of masticatory neuromuscular activation in women of the rheumatoid arthritis group was maintained in rest, protrusion, and dental clenching in maximum voluntary contraction; but in the right and left laterality, it could not be observed, suggesting an incorrect neuromuscular activation[25].

During right and left laterality, there is greater contact of the mandible head against the damaged cartilage or more significant stretching of the ligaments that can cause an increase in painful symptomatology, resulting in possible alterations of the muscular activation pattern[26].

Greater electromyographic activity in the masseter and temporalis muscles in women of the rheumatoid arthritis group was evident in all the studied conditions when compared to women of the non-rheumatoid arthritis group.

The literature shows that the relationship of the functional balance between the articular tubercle of the temporal bone, mandibular fossa, mandible head, capsule and disc, muscle, and accessory ligaments may be compromised by inflammatory cell proliferation, the for-

Table 1: Averages (µV), standard deviation (in brackets, ±), and statistical significance ($p < 0.05$, $p < 0.0001$)* of the normalized electromyographic data (a.u.) of the masticatory muscles in the mandibular tasks for women of the rheumatoid arthritis and the non-rheumatoid arthritis groups.

Mandibular task	Muscles	Groups		p value
		RAG	CG	
Rest	RM	0.23 (0.20)	0.12 (0.10)	
	LM	0.26 (0.22)	0.13 (0.06)	
	p-value	p =0.78	p =0.57	
	Mean both sides	0.25 (0.25)	0.12 (0.85)	0.65
	RT	0.32 (0.20)	0.23 (0.15)	
	LT	0.24 (0.12)	0.22 (0.16)	
	p-value	p =0.19	p =0.90	
	Mean both sides	0.28 (0.17)	0.23 (0.16)	0.29
Right laterality	RM	0.28 (0.21)	0.12 (0.08)	
	LM	0.27 (0.20)	0.24 (0.17)	
	p-value	p =0.78	p =0.007	
	Mean both sides	0.27 (0.24)	0.19 (0.15)	0.25
	RT	0.39 (0.24)	0.30 (0.15)	
	LT	0.19* (0.13)	0.17* (0.09)	
	p-value	p <0.001	p =0.01	
	Mean both sides	0.29[&] (0.21)	0.23 (0.14)	0.0001
Left laterality	RM	0.23 (0.16)	0.17 (0.10)	
	LM	0.22 (0.20)	0.14 (0.08)	
	p-value	p =0.93	p =0.38	
	Mean both sides	0.22 (0.18)	0.16 (0.09)	0.62
	RT	0.33 (0.21)	0.20 (0.13)	
	LT	0.28 (0.23)	0.25 (0.10)	
	p-value	p =0.61	p =0.39	
	Mean both sides	0.30 (0.22)	0.22 (0.12)	0.98
Protrusion	RM	0.39 (0.25)	0.24 (0.20)	
	LM	0.33 (0.27)	0.24 (0.20)	
	p-value	p =0.55	p =0.99	
	Mean both sides	0.36 (0.27)	0.24 (0.19)	0.62
	RT	0.36 (0.19)	0.18 (0.09)	
	LT	0.24 (0.19)	0.18 (0.10)	
	p-value	p =0.13	p =0.90	
	Mean both sides	0.30 (0.20)	0.18 (0.10)	0.14
Dental clenching	RM	0.93 (0.46)	0.70 (0.24)	
	LM	0.83 (0.38)	0.78 (0.20)	
	p-value	p =0.55	p =0.30	
	Mean both sides	0.88 (0.41)	0.74 (0.22)	0.96
	RT	0.98 (0.36)	0.78 (0.23)	
	LT	0.84 (0.39)	0.74 (0.35)	
	p-value	p =0.60	p =0.76	
	Mean both sides	0.74 (0.37)	0.86 (0.29)	0.55

RM: right masseter, LM: left masseter, RT: right temporal muscle, LT: left temporal muscle, RAG: arthritis group, CG: non-rheumatoid arthritis group. *: between sides comparisons, post hoc Bonferroni ($p < 0.05$), [&]: between groups comparisons, post hoc Bonferroni ($p < 0.0001$).

Table 2: Averages (μV), standard deviation (in brackets, ±), and statistical significance ($p < 0.05$)* of the normalized electromyographic data (a.u.) of the masticatory muscles in the chewing for women of the rheumatoid arthritis and the non-rheumatoid arthritis groups.

Chewing	Muscles	Groups		p value
		RAG	CG	
Peanuts	RM	0.80 (0.28)	1.24 (0.38)	
	LM	0.88 (0.38)	1.07 (0.28)	
	p-value	p =0.55	p =0.21	
	Mean both sides	0.84 (0.33)	1.15 (0.34)	0.63
	RT	1.00 (0.45)	1.06 (0.49)	
	LT	0.98 (0.36)	0.88 (0.39)	
	p-value	p =0.92	p =0.30	
	Mean both sides	0.99 (0.40)	0.97 (0.44)	0.36
Parafilm M®	RM	0.82 (0.43)	0.89 (0.37)	
	LM	0.81 (0.35)	0.94 (0.34)	
	p-value	p =0.94	p =0.07	
	Mean both sides	0.82 (0.38)	0.91 (0.35)	0.87
	RT	0.94 (0.56)	1.15 (0.49)	
	LT	0.99 (0.58)	0.82 (0.39)	
	p-value	p =0.82	p =0.11	
	Mean both sides	0.97 (0.56)	0.99 (0.45)	0.32
Raisins	RM	0.71 (0.33)	0.76 (0.39)	
	LM	0.73 (0.36)	0.80 (0.29)	
	p-value	p =0.88	p =0.78	
	Mean both sides	0.72 (0.34)	0.78 (0.34)	0.73
	RT	0.82 (0.39)	1.42 (0.97)	
	LT	0.82 (0.33)	0.79 (0.37)	
	p-value	p =0.98	p =0.11	
	Mean both sides	0.82 (0.36)	1.11 (0.63)	0.12

RM: right masseter, LM: left masseter, RT: right temporal muscle, LT: left temporal muscle, RAG: arthritis group, CG: non-rheumatoid arthritis group.

mation of fibrous granulation tissue, and new vessels in the joint capsule[27]. This creates internal pressure in the structures involved by the capsule, painful symptomatology, functional alteration of the lateral pterygoid muscle fibers which are interspersed with the collagen fibers of the articular disc[28] and functional masticatory instability, resulting in muscular hyperactivity[29]. However, in this study, no magnetic resonance imaging was performed to see if there was any involvement of the disc or the joint capsule.

It is of the utmost importance to perform dynamic and static evaluations of the stomatognathic system to understand the muscular mechanisms in people with chronic degenerative diseases, and to observe possible qualitative changes in the structure of the masticatory muscles[30].

To date, no studies on the masticatory efficiency in adults with rheumatoid arthritis have been reported. In the current study, we evaluated the dynamics of the masticatory movements, consisting of isotonic contractions with periods of isometric contractions, in women with rheumatoid arthritis, using the integrated linear envelope electromyographic signal that is a safe and effective method for the analysis of the electrical activity of the muscles during masticatory cycles[23].

Our results showed a masticatory function decrease in women of the rheumatoid arthritis group. These changes may be related to the natural protective mechanism of avoiding painful symptomatology, and due to edema in the preauricular region reducing the function of the masticatory muscles, leading to progressive deactivation and disuse of the motor units of the muscle fibers.

In this study, 100 % of the women with rheumatoid arthritis presented with preauricular sensitivity, which was observed through digital palpation at the time of the RDC/TMD questionnaire and clinical evaluation. This behavior could justify the reduction in the performance of the masseter and temporal muscles.

The reduction in masticatory efficiency is directly related to a deficiency in the local control of proinflammatory cytokines in the joint capsule, causing hemodynamic and pathophysiological instability, and ischemia. This originates from the stimulation of nerve receptors for pain, during contraction or muscle extension, which leads to increased production of inflammatory cytokines, and ultimately a reduction in functional capacity[31].

Knowing the factors and pathologies that substantially alter the well-being of human beings is a global priority. The analysis of the stomatognathic system has been the objective of studies in groups of people with systemic pathological alterations[32], and therefore, the importance of studying the stomatognathic system of women with rheumatoid arthritis is apparent.

The unprecedented results of the current study will contribute to the knowledge and understanding of the functional behavior of the stomatognathic system, directing with more precision the medical and dental treatments to design clinically relevant strategies.

The study has certain limitations as it exclusively evaluated female subjects; thus the results should also be investigated and verified in male cohorts. Also, the women who were examined by the dentist optimally should have been additionally submitted to sleep studies, neurological, and psychiatric consultation, at the moment of the sample's enrollment/exclusion of subjects. Further studies should be conducted to confirm reported results.

In conclusion, current study suggests that women with rheumatoid arthritis have functional alterations in the masticatory muscles, such as muscle hyperactivity and decrease of masticatory efficiency.

Conflict of interest

Authors declare no conflict of interest.

Acknowledgement

The authors would like to thank the São Paulo Research Foundation (FAPESP).

References

1. Khalid U, Egeberg A, Ahlehoff O, Lane D, Gislason GH, Lip GYH, et al. Incident Heart Failure in Patients With Rheumatoid Arthritis: A Nationwide Cohort Study. J Am Heart Assoc. 2018; 7: pii: e007227.
2. Scott DL, Pugner K, Kaarela K, Doyle DV, Woolf A, Holmes J, et al. The links between joint damage and disability in rheumatoid arthritis. Rheumatology (Oxford). 2000; 39: 122-132.
3. Shin TH, Kim HS, Kang TW, Lee BC, Lee HY, Kim YJ, et al. Human umbilical cord blood-stem cells direct macrophage polarization and block inflammasome activation to alleviate rheumatoid arthritis. Cell Death Dis. 2016; 7: e2524.
4. Abhishek A, Doherty M, Kuo CF, Mallen CD, Zhang W, Grainge MJ. Rheumatoid arthritis is getting less frequent-results of a nationwide population-based cohort study. Rheumatology (Oxford). 2017; 56: 736-744.
5. Gunasekera WM, Kirwan JR. Rheumatoid arthritis: previously untreated early disease. BMJ Clin Evid. 2016; 2016: pii: 1124.
6. Muñoz JGB, Giraldo RB, Santos AM, Bello-Gualteros JM, Rueda JC, Saldarriaga EL, et al. Correlation between rapid-3, DAS28, CDAI and SDAI as a measure of disease activity in a cohort of Colombian patients with rheumatoid arthritis. Clin Rheumatol. 2017; 36: 1143-1148.
7. Rosado-de-Castro PH, Lopes de Souza SA, Alexandre D, Barbosa da Fonseca LM, Gutfilen B. Rheumatoid arthritis: Nuclear Medicine state-of-the-art imaging. World J Orthop. 2014; 5: 312-318.
8. Brenol CV, da Mota LM, Cruz BA, Pileggi GS, Pereira IA, Rezende LS, et al. 2012 Brazilian Society of Rheumatology Consensus on vaccination of patients with rheumatoid arthritis. Rev Bras Reumatol. 2013; 53: 4-23.
9. Almeida Mdo S, Almeida JV, Bertolo MB. [Demographic and clinical features of patients with rheumatoid arthritis in Piauí, Brazil--evaluation of 98 patients]. Rev Bras Reumatol. 2014; 54: 360-365.
10. Anyfanti P, Pyrpasopoulou A, Triantafyllou A, Chatzimichailidou S, Aslanidis S, Douma S. Acute inflammatory arthritis in the elderly; Old flames, new sparks. Hippokratia. 2014; 18: 231-233.
11. Bracco P, Debernardi C, Piancino MG, Cirigliano MF, Salvetti G, Bazzichi L, et al. Evaluation of the stomatognathic system in patients with rheumatoid arthritis according to the research diagnostic criteria for temporomandibular disorders. Cranio. 2010; 28: 181-186.
12. Marotte H. [The temporomandibular joint and inflammatory rheumatic diseases]. Rev Stomatol Chir Maxillofac Chir Orale. 2016; 117: 223-227.
13. da Mota LM, Cruz BA, Brenol CV, Pereira IA, Fronza LS, Bertolo MB, et al. 2011 Consensus of the Brazilian Society of Rheumatology for diagnosis and early assessment of rheumatoid arthritis. Rev Bras Reumatol. 2011; 51: 199-219.
14. Mendes da Silva J, Pérola Dos Anjos Braga Pires C, Angélica Mendes Rodrigues L, Palinkas M, de Luca Canto G, Batista de Vasconcelos P, et al. Influence of mandibular tori on stomatognathic system function. Cranio. 2017; 35: 30-37.
15. Hennes M, Bollue K, Arenbeck H, Disselhorst-Klug C. A proposal for patient-tailored supervision of movement performance during end-effector-based robot-assisted rehabilitation of the upper extremities. Biomed Tech (Berl). 2015; 60: 193-197.
16. Siéssere S, Sousa LG, Lima Nde A, Semprini M, Vasconcelos PB, Watanabe PC, et al. Electromyographic activity of masticatory muscles in women with osteoporosis. Braz Dent J. 2009; 20: 237-342.
17. Hong J, Huang Y, Ma C, Qu G, Meng J, Wu H, et al. Risk factors for anterior shoulder instability: a matched case-control study. J Shoulder Elbow Surg. 2019; 28(5): 869-874
18. Manfredini D, Winocur E, Ahlberg J, Guarda-Nardini L, Lobbezoo F. Psychosocial impairment in temporomandibular disorders patients. RDC/TMD axis II findings from a multicentre study. J Dent. 2010; 38: 765-772.
19. Hermens HJ, Freriks B, Disselhorst-Klug C, Rau G. Development of recommendations for SEMG sensors and sensor placement procedures. J Electromyogr Kinesiol. 2000; 10: 361-374.
20. Palinkas M, Bataglion C, de Luca Canto G, Machado Camolezi N, Theodoro GT, Siéssere S, et al. Impact of sleep bruxism on masseter and temporalis muscles and bite force. Cranio. 2016; 34: 309-315.
21. Di Palma E, Tepedino M, Chimenti C, Tartaglia GM, Sforza

C. Effects of the functional orthopaedic therapy on masticatory muscles activity. J Clin Exp Dent. 2017; 9: e886-e891.

22. Galo R, Vitti M, Mattos Mda G, Regalo SC. Masticatory muscular activation in elderly individuals during chewing. Gerodontology. 2007; 24: 244-248.
23. Palinkas M, Cecilio FA, Siéssere S, Borges Tde F, de Carvalho CA, Semprini M, et al. Aging of masticatory efficiency in healthy subjects: electromyographic analysis--Part 2. Acta Odontol Latinoam. 2013; 26: 161-166.
24. Barn R, Brandon M, Rafferty D, Sturrock RD, Steultjens M, Turner DE, et al. Kinematic, kinetic and electromyographic response to customized foot orthoses in patients with tibialis posterior tenosynovitis, pes plano valgus and rheumatoid arthritis. Rheumatology (Oxford). 2014; 53: 123-130.
25. Cecílio FA, Regalo SC, Palinkas M, Issa JP, Siéssere S, Hallak JE, et al. Ageing and surface EMG activity patterns of masticatory muscles. J Oral Rehabil. 2010; 37: 248-255.
26. Hirsch C, John MT, Lautenschläger C, List T. Mandibular jaw movement capacity in 10-17-yr-old children and adolescents: normative values and the influence of gender, age, and temporomandibular disorders. Eur J Oral Sci. 2006; 114: 465-470.
27. Goronzy JJ, Weyand CM. Thymic function and peripheral T-cell homeostasis in rheumatoid arthritis. Trends Immunol. 2001; 22: 251-255.
28. Sakaguchi-Kuma T, Hayashi N, Fujishiro H, Yamaguchi K, Shimazaki K, Ono T, et al. An anatomic study of the attachments on the condylar process of the mandible: muscle bundles from the temporalis. Surg Radiol Anat. 2016; 38: 461-467.
29. Cao Y, Zhang W, Yap AU, Xie QF, Fu KY. Clinical characteristics of lateral pterygoid myospasm: a retrospective study of 18 patients. Oral Surg Oral Med Oral Pathol Oral Radiol. 2012; 113: 762-765.
30. de Oliveira RH, Hallak JE, Siéssere S, de Sousa LG, Semprini M, de Sena MF, et al. Electromyographic analysis of masseter and temporal muscles, bite force, masticatory efficiency in medicated individuals with schizophrenia and mood disorders compared with healthy controls. J Oral Rehabil. 2014; 41: 399-408.
31. Ahmed N, Catrina AI, Alyamani AO, Mustafa H, Alstergren P. Deficient cytokine control modulates temporomandibular joint pain in rheumatoid arthritis. Eur J Oral Sci. 2015; 123: 235-241.
32. Rinaldi LA, Simoni D, Maresca M, Monaco V, Matucci-Cerinic M, Melchiorre D. Gait abnormalities in early rheumatoid arthritis with temporomandibular joint involvement. Clin Exp Rheumatol. 2016; 34: 561.