Rheumatoid Arthritis and Osteoarthritis in Adult Women: A Functional Approach to the Stomatognathic System

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Abstract: Rheumatoid arthritis and osteoarthritis both affect the articular cartilage, and are characterized by signs and symptoms that can affect the functions of the human body. This cross-sectional observational study evaluated electromyographic activity in the masseter and temporalis muscles, molar bite force, and mandibular mobility in adult women with rheumatoid arthritis or osteoarthritis. A total of 42 women were distributed into 3 groups: rheumatoid arthritis group (ARG, n=14); osteoarthritis group (OAG, n=14); and a healthy control group (CG, n=14). Electromyography was used to evaluate mandibular tasks at rest, right and left laterality, protrusion, and dental clenching during maximum voluntary contraction, with and without parafilm, and a dynamometer was used to analyse the right and left molar bite forces. A digital caliper was used to measure the range of mandibular movement for maximum mouth opening, right and left laterality, and protrusion. Statistical analyses were performed, including analysis of variance and Tukey's test ($P<0.05$).

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Electromyography showed no significant differences between the groups when evaluating the masticatory muscles during the mandibular tasks. Significant difference was observed between the ARG and CG, however, in the maximum right (P=0.007) and left (P=0.02) molar bite forces. Significant difference was observed in the maximum mouth opening of the ARG and OAG groups compared with that of the CG (P=0.009), suggesting that adult women with rheumatoid arthritis or osteoarthritis experience functional alterations in the stomatognathic system, particularly in molar bite force and maximum mouth opening.

Introduction

Rheumatoid arthritis and osteoarthritis are both chronic diseases that affect the musculoskeletal system, particularly the joint cartilage, of individuals with a family history, often involving the temporomandibular joints and structures that comprise the stomatognathic system (Bruno et al., 2022).

Rheumatoid arthritis is an inflammatory disease that results in functional damage to cartilage and bones (Smolen et al., 2016; Palinkas et al., 2018). It is one of the most common autoimmune diseases, affecting approximately 1% of the world's population. In the United States, approximately 1.28–1.36 million adults are affected (Hunter et al., 2017). Individuals with rheumatoid arthritis experience joint pain and stiffness, with morning stiffness lasting more than an hour being an important clinical characteristic related to the disease's inflammatory etiology (Aletaha and Smolen, 2018).

Osteoarthritis is the most commonly diagnosed joint disease in the world, with an age-associated increase in incidence and prevalence (Mandl, 2019), characterized by the degeneration of joint cartilage, which causes a decrease in joint spaces, friction between bones, pain, edema, and functional disability (Musumeci et al., 2015). It is the most frequent disease of the musculoskeletal system, and can affect at multiple joints with cartilage at any time (Fernández-Torres et al., 2017; Vina and Kwoh, 2018).

Functional analyses of the stomatognathic system in individuals with chronic degenerative diseases are performed using internationally recognized assessments, such as gnathodynamometry, range of mandibular movements, and masticatory performance, to obtain accurate diagnoses and more effective treatment results (Zhao and Monahan, 2007; Righetti et al., 2020; Gonçalves et al., 2022). Therefore, studies which aim to demonstrate the influence of chronic degenerative diseases on the stomatognathic system are relevant, because they aim to verify changes in the performance patterns relating to masticatory mechanics, as well as possible influences on the effectiveness of rehabilitation treatments in different areas of health. The null hypothesis of the present study was that adult women with rheumatoid arthritis or osteoarthritis do not present with functional changes in the stomatognathic system.

Material and Methods

The protocol for the present cross-sectional observational study was approved by the ethics committee of the Faculty of Dentistry of Ribeirão Preto, University of São Paulo, Brazil (Process # 67983717.2.0000.5419). Written informed consent was obtained from all the women who participated in the study.

Convenience sample selection

In the initial phase of the present study, 174 adult women from the cities of Ribeirão Preto, Batatais, and Bebedouro in the State of São Paulo, Brazil were recruited and evaluated – 102 with a diagnosis of rheumatoid arthritis, 72 with a diagnosis of osteoarthritis. Based on the established exclusion criteria, 88 women with rheumatoid arthritis and 58 with osteoarthritis were excluded from the present study.

In total, 42 women, 40–70 years of age, participated in the present study. The patients were divided into the following three groups: rheumatoid arthritis group (ARG, n=14); osteoarthritis group (OAG, n=14); and a group of health controls (CG, n=14). For the ARG group, the mean age was 52.3 ± 11.2 years, and the mean body mass index (BMI) was 31.1 ± 4.64 kg/m^2; for the OAG group, the mean age and BMI were 54 ± 6.8 years and 27.3 ± 3.93 kg/m^2, respectively; and for the CG group, the mean age and BMI were 50.2 ± 9.5 years and 27.2 ± 3.88 kg/m^2, respectively. For the group constitution, pairing by age and BMI was considered. BMI was calculated in kilograms and meters, as follows: BMI = weight in kilograms/(height in meters) × (height in meters).

Women with chronic degenerative diseases were diagnosed by rheumatologists after evaluating clinical signs and symptoms, imaging, and laboratory tests (da Mota et al., 2011). A clinical intake form was used to collect personal information, such as the general and oral health history, existence of additional uncompensated systemic diseases, and parafunctional habits. The Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) were used to rule out temporomandibular disorders (Yap et al., 2023). The DC/TMD was applied to the patients in all three groups as a diagnostic criterion for temporomandibular dysfunction.

The exclusion criteria were as follows: absence of the first permanent molars, upper or lower; dental restoration with a risk of fracture; presence of temporomandibular disorder; orthodontic, speech therapy, or otorhinolaryngological treatment; use of medications that could interfere with muscle activity; physical or emotional indisposition to perform the tests; and clinical history of psychiatric or neurological disorders.

The post hoc sample calculation was performed using G*Power software, version 3.1.9.7 (Franz Faul, Kiel University, Kiel, Germany) to ensure that a representative sample was used. For the post hoc sample calculation, the values obtained for the maximum right bite force from the ARG (153 ± 27) and OAG (211 ± 27) groups, with an error of 5%, were considered. According to the analysis protocol issued by the software, the effect size was 2.23 and the test power was 99%. The intra-examiner reliability was assessed by calculating the intraclass coefficient (ICC), and the reliability was considered acceptable for electromyographic activity (EMG) (ICC = 0.936).

Electromyographic analysis of mandibular tasks

The EMG evaluation of the masseter and temporalis muscles was performed by a single trained professional using the TrignoTM Wireless EMG System (Delsys, Inc., Natick, Massachusetts, USA). The electromyographic recording allowed us to evaluate the EMG of the masticatory muscles during the following mandibular tasks: rest (4 s); right (10 s) and left laterality (10 s); protrusion (10 s), and dental clenching in maximum voluntary contraction with (4 s) and without (4 s) an inert material. The inert material (Parafilm; Pechiney Plastic Packaging, Batavia, IL, USA) consisted of a folded sheet of paraffin (18×17×4 mm, 245 mg) placed between the permanent molars (upper and lower) on both sides of the dental arch (Siéssere et al., 2009).

To obtain EMG data, surface electrodes were installed in the belly regions of the masseter and temporalis muscles on both sides of the mouth using the maximum voluntary contraction maneuver and digital palpation, which is considered the best point for investigation (Hermens et al., 2000). Superficial aseptic cleaning was performed using 70% isopropyl alcohol before fixing the electrodes, in order to reduce the electrical impedance of the biological tissues (Di Palma et al., 2017).

EMG data were acquired in a calm environment, with the patients sitting erectly on a chair, and breathing lightly and slowly. The head was positioned in the Frankfurt plane, the hands were lightly supported on the anterior region of the thighs, and the feet were placed on the ground.

Molar bite force analysis

An IDDK model digital dynamometer (Kratos Equipamentos Industriais Ltda., Cotia, São Paulo, Brazil) was used to measure the maximum bite force, adjusted for the oral cavity to avoid condylar displacement or muscle distension. The dynamometer contained two rods with two Teflon disks at their ends, to which the bite force was applied, which was recorded in Newtons (N) (Palinkas et al., 2010; Gomes et al., 2022).

The patients were seated erectly on a comfortable chair with their feet flat on the floor and their hands rested on the anterior region of their thighs. To ensure sanitary conditions, the device's rods were aseptically cleaned with 70% isopropyl alcohol prior to each collection, in addition to being covered with disposable latex finger cots.

The rods were positioned over the region of the first permanent molar, which provides the greatest occlusal force (Regalo et al., 2008). The patients were asked to bite the device with their maximum effort three times, with a two-minute rest period between recordings, and alternating between the right and left sides (Bonjardim et al., 2009). All patients were instructed in advance to perform the tests by squeezing the device between their teeth before obtaining official records to ensure the reliability of the procedure.

Analysis of the range of mandibular movements

The amplitude of the patients' mandibular movements, in millimeters, was evaluated based on the mean value obtained from three measurements using a digital caliper (Mitutoyo®, Suzano, São Paulo, Brazil) during the mandibular tasks of maximum mouth opening, right and left laterality, and protrusion. Before each evaluation, the procedure was explained to the patients, and for reference standardization, dental midlines were adopted, along with the deviations. The equipment was positioned at the incisal and mesial regions of the upper and lower central incisors (Mazzetto et al., 2017).

Statistical analysis

The raw EMG data were used to determine the values for amplitude, using the root mean square (RMS) in microvolts (µV) per second. To allow for comparison, the RMS value obtained during the tooth clenching at maximum voluntary contraction was used to normalize the data obtained during the mandibular tasks. Statistical analyses were performed using GraphPad Prism software (GraphPad Software Inc., version 5.0, California, USA). The results were compared using analysis of variance (ANOVA), with a significance level of 5% and a confidence interval of 95%, and a post hoc comparison was performed using Tukey's test.

Results

Table 1 shows the normalized electromyographic activity of the masseter and temporalis muscles during mandibular tasks for the rheumatoid arthritis (ARG), osteoarthritis (OAG), and control (CG) groups. There were no significant differences in the normalized EMG of the masticatory muscles between the groups. Clinical analysis showed that the ARG group showed higher normalized EMG values during rest, right and left laterality, and protrusion in the temporal and right masseter muscles, and lower values in dental clenching in maximum voluntary contraction with parafilm compared to the OAG and CG groups for all masticatory muscles.

In the analysis of the maximum molar bite force, the ARG group showed less force on the right ($P=0.007$) and left ($P=0.02$) sides compared to the OAG and CG groups, with a significant difference when compared with the CG group. The OAG group presented a lower bite force than the CG group on both sides; however, the difference was not significant (Table 2).

Table 3 shows the range of mandibular movements in the ARG, OAG, and CG groups. A significant difference was observed for the maximum mouth opening among the three groups (P=0.009), although no significant differences were observed for right and left laterality or protrusion between the groups.

Discussion

The null hypothesis of the present study, that adult women with rheumatoid arthritis or osteoarthritis do not present with functional changes in the stomatognathic

Table 1 – Differences in mean values (standard error) of normalized EMG data between groups

Mandibular task Muscles	Groups			P-value
	ARG mean ± standard error	OAG mean ± standard error	CG mean ± standard error	
Rest				
RM	0.20 ± 0.03	0.14 ± 0.04	0.12 ± 0.02	0.23
LM	0.21 ± 0.07	0.21 ± 0.05	0.13 ± 0.02	0.43
RT	0.34 ± 0.06	0.27 ± 0.06	0.20 ± 0.05	0.24
LT	0.24 ± 0.03	0.21 ± 0.04	0.19 ± 0.04	0.60
Protrusion				
RM	0.39 ± 0.07	0.21 ± 0.06	0.23 ± 0.04	0.08
LM	0.33 ± 0.10	0.28 ± 0.07	0.24 ± 0.06	0.71
RT	0.51 ± 0.18	0.24 ± 0.05	0.18 ± 0.03	0.09
LT	0.27 ± 0.05	0.21 ± 0.04	0.17 ± 0.04	0.47
Right laterality				
RM	0.25 ± 0.06	0.12 ± 0.03	0.13 ± 0.03	0.06
LM	0.23 ± 0.06	0.23 ± 0.05	0.22 ± 0.04	0.99
RT	0.39 ± 0.06	0.24 ± 0.05	0.26 ± 0.04	0.99
LT	0.20 ± 0.04	0.19 ± 0.03	0.15 ± 0.03	0.45
Left laterality				
RM	0.20 ± 0.03	0.14 ± 0.04	0.21 ± 0.04	0.06
LM	0.22 ± 0.07	0.18 ± 0.05	0.14 ± 0.03	0.06
RT	0.40 ± 0.12	0.24 ± 0.05	0.22 ± 0.05	0.23
LT	0.29 ± 0.06	0.23 ± 0.05	0.23 ± 0.03	0.71
MVC/parafilm				
RM	0.83 ± 0.12	1.40 ± 0.32	1.09 ± 0.25	0.27
LM	0.78 ± 0.11	1.53 ± 0.38	1.09 ± 0.25	0.06
RT	0.85 ± 0.14	1.15 ± 0.34	1.22 ± 0.38	0.68
LT	0.71 ± 0.11	1.11 ± 0.27	1.27 ± 0.49	0.47

EMG – electromyographic activity; ARG – rheumatoid arthritis; OAG – osteoarthritis; CG – without the diseases, control; RM – right masseter; LM – left masseter; RT – right temporalis; LT – left temporalis; MVC – maximum voluntary contraction. Significant difference, ANOVA and Tukey's post-test (i.e., P<0.05)

Table 2 – Differences in mean values (standard error) of molar bite force data between groups

Molar bite force (N)	Groups			P-value
	ARG mean ± standard error	OAG mean ± standard error	CG mean ± standard error	
Right	153 ± 27[a]	211 ± 27	260 ± 12[b]	0.007
Left	149 ± 33[a]	217 ± 24	252 ± 17[b]	0.020

ARG – rheumatoid arthritis; OAG – osteoarthritis; CG – without the diseases, control; N – newtons.
Significant difference, ANOVA and Tukey's post-test ([a] and [b] – difference between groups) (i.e., $P<0.05$)

Table 3 – Differences in mean values (standard error) of range of mandibular movements data between groups

Mandibular tasks (mm)	Groups			P-value
	ARG mean ± standard error	OAG mean ± standard error	CG mean ± standard error	
Maximum mouth opening	36.4 ± 1.7[a]	36.7 ± 1.7[a]	43.0 ± 1.6[b]	0.009
Protrusion	6.2 ± 1.0	5.2 ± 0.6	6.7 ± 0.6	0.360
Right laterality	7.6 ± 0.9	7.8 ± 0.8	9.3 ± 0.8	0.220
Left laterality	8.7 ± 1.2	9.5 ± 0.8	8.9 ± 0.7	0.360

ARG – rheumatoid arthritis; OAG – osteoarthritis; CG – without the diseases, control; mm – millimeters.
Significant difference, ANOVA and Tukey's post-test ([a] and [b] – difference between groups) (i.e., $P<0.05$)

system, was rejected, based on the results found for the various methodologies used, which demonstrated that this specific population does, in fact, present with changes in the functionality of the stomatognathic system, particularly in the molar bite force and maximum mouth opening. The present study used a variety of internationally standardized techniques to accurately assess the stomatognathic system of the study population, including evaluations of the masticatory muscles, bite force, and range of mandibular movements.

At rest, it was possible to observe a record of normalized EMG activity of both the masseter and temporalis muscles in all groups, as reported in the literature (Palinkas et al., 2013; Gonçalves et al., 2018). This finding is expected because it is necessary to recruit muscle fibers in both muscles to maintain this postural condition. Although there was no significant difference between the groups, there was greater EMG activation of the temporalis muscles in relation to the masseters in all groups, which is consistent with the literature (Cecílio et al., 2010).

When evaluating protrusion, no significant differences were observed between the three groups; however, higher normalized means of the EMG data from the right temporal muscle were observed in relation to the right masseter muscle in the ARG and OAG groups. This finding differs from the typical pattern of EMG activation, in which greater activity of the masseter muscle is expected compared to the temporalis muscle (Cecílio et al., 2010). In the control group, however, the pattern was as expected, with greater activity in the masseter than the temporalis muscles.

In evaluating right and left laterality, the typical pattern of behaviour is that the temporalis muscle is more active on the same side to which the mandible is projected (working side), while the masseter muscle is more active on the opposite side, to which the mandible extends (balance side) (Blanksma et al., 1995). The results of the present study showed that in this mandibular task, the results were in line with what is expected for right laterality in the OAG and CG groups, based on the relevant literature, except for the right masseter muscle in the ARG group. On the left side, the normalized means of the EMG data for the ARG and OAG groups were the opposite of the expected pattern, which was thought to be the result of systemic compensation when performing the requested function, in turn recruiting more muscle fibers contralaterally.

Although no significant differences were found in the tooth-clenching task at maximum voluntary contraction, the activity of the masseter muscle in the OAG group tended to dominate at greater clenching intensities, which is in agreement with the relevant literature (Mioche et al., 1999).

Bite force is used to understand a wide range of factors of the masticatory system (Jansen van Vuuren et al., 2020), including the maximum load performance in the region of the first molars, which determines the efficiency of this system (Regalo et al., 2008; Pepato et al., 2014). Bite force is a fundamental factor in masticatory tasks, and depends on muscle volume, activity, and coordination, as well as mandibular mobility, as all these factors are important in the of fractionation food (van der Bilt et al., 2006).

The results of the present study showed weaker left molar bite forces, with a significant difference between the ARG and CG groups. The importance of evaluating the functional and parafunctional mandibular loads that oral diseases and dysfunctions are partially related to these loads (Hattori et al., 2009).

Bite force is produced by muscle coactivation, predominantly the masseter, medial pterygoid, and temporalis muscles (Peck, 2016). Since the generation of potential force in these muscles closer to the mandible is related to the size of the cross-section and the length of the muscle, it is important to correlate degenerative diseases that affect the musculoskeletal components and the impaired ability to apply forces to cut and grind food.

Mandibular range of motion requires neuromuscular control of the masticatory muscles, since, for the execution of masticatory activity, a combination of muscle activities is necessary for the mandible to move and exert enough force to cut or crush food (van der Bilt et al., 2006). In the present study, lower means of maximum mouth opening were observed, identifying a significant difference in the ARG and OAG in relation to the CG. Therefore, the assessment of mandibular mobility is an integral part of dental examinations (Türp et al., 2020), especially in patients with chronic degenerative diseases.

The process of aging involves significant changes in several physiological functions, which decrease the body's ability to maintain homeostasis, increasing an individual's predisposition to disease and, consequently, death. The skeletal muscles are particularly affected by aging, especially with regard to the decrease in muscle mass and strength, which is characterized by sarcopenia (Scicchitano et al., 2018).

Although sarcopenia is frequently observed, it is one of the main determinants of several adverse effects of aging, such as frailty, disability, and limitations in the activities of daily life, all of which affect quality of life (Azzolino et al., 2019). It is important to emphasize that sarcopenia involves the entire body, affecting both the masticatory muscles and maximum molar bite force (Fan et al., 2022).

The relationship between oral disease and sarcopenia can be observed by the common presentation of inflammation and oxidative stress, which are related to biological and environmental factors. Poor oral health affects food selection, which is directly related to nutrient intake, in turn resulting in malnutrition, frailty, and sarcopenia (Azzolino et al., 2019).

Although the present study did not evaluate for the presence of sarcopenia, the patients were diagnosed with a chronic degenerative disease (rheumatoid arthritis or osteoarthritis), which is correlated with aging and oxidative stress (Phull et al., 2018; Brance et al., 2021). The role of oxidative stress in the pathophysiology of aging is complex, involving the agglutination of reactive oxygen species and a reduction in antioxidant mechanisms (Scicchitano et al., 2018). Furthermore, previous studies have suggested that the interaction between oxidative stress, chronic inflammation, and mitochondrial dysfunction can affect the balance between protein synthesis and protein breakdown, inducing apoptosis, in addition to causing atrophy and loss of fibers in aging skeletal muscles (Nishikawa et al., 2021).

Therefore, changes related to the aging process that affect joint tissues predispose patients to rheumatoid arthritis and osteoarthritis. The reduction in muscle mass and increase in fat mass that occur with aging result in an increased joint load, with a subsequent increase in the production of adipokines and cytokines, resulting in low-grade systemic inflammation. Additionally, elevated levels of reactive oxygen species can contribute to osteoarthritis by promoting oxidative stress (Loeser et al., 2016).

In contrast, oxidative stress has been shown to be a potential contributor to the initiation and establishment of a pro-inflammatory milieu in individuals with rheumatoid arthritis, which is defined as a high-grade condition (da Fonseca et al., 2019). These findings corroborate the results of the present study, as both diseases have potential effects on the components of the stomatognathic system, which was more evident when analysing ARG in relation to OAG and CG.

The present study has some limitations. Of note, the presence of osteoarthritis or rheumatoid arthritis in the temporomandibular joints was not evaluated, nor was the status of unilateral or bilateral involvement. In the case of rheumatoid arthritis, magnetic resonance imaging (MRI) should be used as part of the diagnostic process, as it is the only test capable of detecting bone marrow edema, which is a good predictor of disease progression. Additionally, MRI is a safe and appropriate tool for monitoring responses to the treatment of synovial and erosive progression (Barile et al., 2017). For osteoarthritis, the most recommended diagnostic method is computed tomography (Haj-Mirzaian et al., 2020). This study utilized a women-only sample; therefore, it is recommended to investigate and verify the results in men patients to achieve a comprehensive understanding of the findings.

Conclusion

The results of the present study suggest that adult women with chronic degenerative diseases of the joint cartilage (rheumatoid arthritis or osteoarthritis) undergo functional changes in the stomatognathic system, with an emphasis on changes to the maximum molar bite force and maximum mouth opening range.

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