conscientiae saúde eISSN: 1983-9324

https://doi.org/10.5585/conssaude.v21n1.23393

Recebido em: 04 dez. 2022 - Aprovado em: 11 abr. 2023
Editora Chefe: Daniela Aparecida Biasotto-Gonzalez
Editor Científico: Cid André Fidelis de Paula Gomes

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RATIO BETWEEN MAXIMUM JAW OPENING AND LATERAL EXCURSION IN BRAZILIANS WITH AND WITHOUT TEMPOROMANDIBULAR DISORDER

RAZÃO ENTRE ABERTURA MÁXIMA E EXCURSÃO LATERAL MANDIBULAR EM BRASILEIROS COM E SEM DISFUNÇÃO TEMPOROMANDIBULAR

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Abstract

Background: Mandibular movements (MM) can offer important information regarding temporomandibular joint health.
Objective: Evaluate MM and the ratio between maximum jaw opening and mandibular lateral excursion in Brazilians with and without temporomandibular disorder (TMD).
Methods: A cross-sectional study was conducted with 801 individuals between five and 80 years. All individuals answered a screening questionnaire; and MM were measured using digital calipers. The Mann-Whitney test was used to compare the differences between the sexes and groups with and without TMD. The Kruskal-Wallis test was used to determine differences in MM among age groups.
Results: MM were smaller in individuals with TMD than in those without TMD. The ratio between jaw opening and lateral excursion was 5.23 in women without TMD and 5.59 in women with TMD. In males, the ratio was 4.75 and 5.52 in individuals without and with TMD, respectively.
Conclusion: MM are smaller in Brazilians with TMD, whereas the ratio between jaw opening and lateral excursion is larger.

Keywords: Temporomandibular Joint. Temporomandibular Joint Disorders. Joint Range of Motion. Mandible.

Resumo

Introdução: Os movimentos mandibulares (MM) podem oferecer informações importantes sobre a articulação temporomandibular.
Objetivo: Avaliar os MM e a relação entre abertura máxima e excursão lateral mandibular em brasileiros com e sem disfunção temporomandibular (DTM).
Métodos: Estudo transversal com 801 brasileiros entre cinco e 80 anos. Os indivíduos responderam um questionário de triagem; e os MM foram medidos com paquímetro digital. O teste de Mann-Whitney foi utilizado para comparar diferenças entre sexos e grupos com e sem DTM. O teste de Kruskal-Wallis foi aplicado para determinar diferenças nos MM entre faixas etárias.
Resultados: Os MM foram menores nos indivíduos com DTM. A razão entre abertura mandibular e excursão lateral foi de 5,23 em mulheres sem DTM e 5,59 em mulheres com DTM. Nos homens, a proporção foi de 4,75 e 5,52 em indivíduos sem e com DTM, respectivamente.
Conclusão: Os MM são menores em brasileiros com DTM, enquanto que a relação entre abertura mandibular e excursão lateral é maior.

Descritores: Articulação Temporomandibular. Transtornos da Articulação Temporomandibular. Amplitude de Movimento Articular. Mandíbula.

Cite como
Vancouver

Cunha, TA, Tosato, JP, Leonardis, MN, Martins, RCN, Silva, JL, Spinato, IL, Politti, F, Biasotto-Gonzalez, DA. Ratio between maximum jaw opening and lateral excursion in brazilians with and without temporomandibular disorder. *Conscientiae Saúde* 2022;21(1):1-14, e23393. https://doi.org/10.5585/conssaude.v21n1.23393.

Introduction

The temporomandibular joint (TMJ) is formed by the condyle of the jaw, temporal fossa, and other structures that ensure its stability and functioning, such as the joint disk, capsule, ligaments, and muscles. Diverse arthrokinematic combinations of the TMJ (especially rotation and translation) result in the mandibular movements of opening, closing, lateral excursion, protrusion, and retrusion, which are directly related to the main functions of the TMJ, such as chewing, speaking, and yawning[1-3]. Joint mobility is essential to the functioning of the stomatognathic system and is generally evaluated based on the mandibular range of motion[2].

The most common measures are maximum jaw opening, lateral excursion, and protrusion, as they can offer meaningful information regarding TMJ health and the structures related to it[4]. These movements are usually measured using a ruler or caliper, using the central incisor teeth as a reference[5]. On jaw opening, occurs rotation and translation of the condyle, while horizontal movements occur mainly through the translation of the condyle in relation to the temporal fossa[1]. However, kinematic studies suggest that the movement of the incisors during lateral excursion is more related to the condylar translation than the movement of the incisors during the opening[6,7].

This data demonstrates that horizontal movements may better reflect joint dysfunctions (intracapsular), and opening movement, muscle alterations (extracapsular)[8]. Based on this, once the expected ratio between opening and lateral excursion is known, it can be analyzed whether there is a loss of intra- or extra-articular functionality. This value was initially established as 4:1 and questioned later by other authors who observed higher values, from 5.1: 1 to 6:1 in healthy individuals[4,5,9].

Thus, the evaluation of these mandibular movements is common in studies addressing temporomandibular disorders (TMD), as a reduction in range of motion is commonly found in these individuals. Some studies have observed significant differences in the mandibular range of motion between individuals with and without TMD[8-11]. However, only one study evaluated the ratio between opening and lateral excursion in individuals with TMD and found no significant differences between individuals with and without this dysfunction[9]. Even so, this study included only individuals with myofascial TMD, limiting the assessment of a larger portion of this population.

Such data show that the ratio between opening and lateral excursion of these individuals is still unknown and that this value is controversial in healthy individuals. As the reduction in the movements of the TMJ is consistently cited as a sign of TMD and a goal for improvement

in therapeutic programs[12,13], we hypothesize that the ratio between jaw opening and lateral excursion does not alter in individuals with TMD, presenting a reduction in both mandibular movements. We also hypothesize that the mandibular range of motion differs between the sexes and age groups. Therefore, the present study aimed to evaluate and compare jaw movements and the ratio between maximum jaw opening and mandibular lateral excursion in Brazilians with and without TMD, as well as to compare the range of motion between individuals of different age groups and genders.

Methods

The present cross-sectional study received approval from the institutional review board of *Universidade Nove de Julho* (UNINOVE) (certificate number: 36876914.1.00005511) and is in compliance with the Helsinki Declaration. All volunteers received clarifications regarding the objectives and procedures and agreed to participate by signing a statement of informed consent. This study was conducted following the recommendations of the STROBE statement[14] and was conducted at Support Center for Research in Movement Analysis at UNINOVE, São Paulo, SP, Brazil.

The sample was composed of Brazilian men and women between five and 80 years of age with and without TMD according to the short-form Fonseca Anamnestic Index (SFAI)[15], an instrument with a high level of accuracy (AUC = 0.97) for the diagnosis of TMD[16]. This instrument is composed of 5 questions that are easy to administer and understand. Each item has three scored response options (yes = 10, sometimes = 5, and no = 0). The sum of the items is used to classify the individuals: 0-10 points = absence of TMD, and 15-50 points = presence of TMD[16].

Subjects were recruited from physiotherapy and dentistry clinics at UNINOVE, private clinics, university students, and randomly in the city of São Paulo. Initially, patients were screened using the SFAI, and a clinical evaluation was carried out by an expert in the field, which included muscle palpation, assessment of mandibular movements, joint palpation, and patient history. Individuals were considered with TMD when presenting at least 15 points according to the SFAI and one or more of the following clinical findings: muscle pain, joint pain, joint noise, or jaw movement with deviation (corrected or uncorrected). Individuals without TMD should present 0 to 10 points in the SFAI, no muscle or joint pain on palpation, no alteration in the mandibular movement, and no joint noises. Individuals with a history of

trauma and/or surgery in the head and individuals without the cognitive ability to answer a self-perception instrument were excluded from the total sample.

Maximum opening and lateral excursion of the jaw were then measured using digital calipers (Starrett®, São Paulo, BR) following the recommendations for items E4b, E5a, and E5b of the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD)[17]. Each measurement was made three times with a five-minute rest interval between readings - in order to avoid movement flaws - and the mean of the three readings was used for the analysis (as performed in the reliability test, described later). The maximum opening was defined by the sum of the vertical incisal overlap and the interincisal distance[5].

Reliability test

The reliability test for measuring the jaw's maximum opening and lateral excursion was performed with ten healthy individuals (no TMD signs or symptoms) between 18 and 22 years of age. For the measurements, the participant was instructed to remain sitting, feet supported on the floor, arms relaxed, and hands positioned on the legs. The measurements were made by three experienced physiotherapists. The order of the measurements among the evaluators was determined by lots. During the test session, each evaluator performed three measurements with a five-minute rest interval between readings, and the mean was calculated among the three readings for the determination of the final value.

Statistical analysis

The Shapiro-Wilk test was used to determine the normality of the data. The reliability of the jaw's maximum opening and lateral excursion was quantified using the interclass correlation coefficient (ICC) and the standard error of the mean (SEM). ICCs were calculated using the $ICC_{2,1}$ method[18] and the SEM was estimated by subtracting the ICC from 1, taking the square root of the value and multiplying by the standard deviation (SD) ($SEM = SD\sqrt{1-ICC}$)[19]. For the present study, the ICC was interpreted as follows: 0.00-0.39 = weak correlation; 0.40-0.59 = moderate correlation; 0.60-0.74 = strong correlation; and 0.75-1.00 = excellent correlation[20].

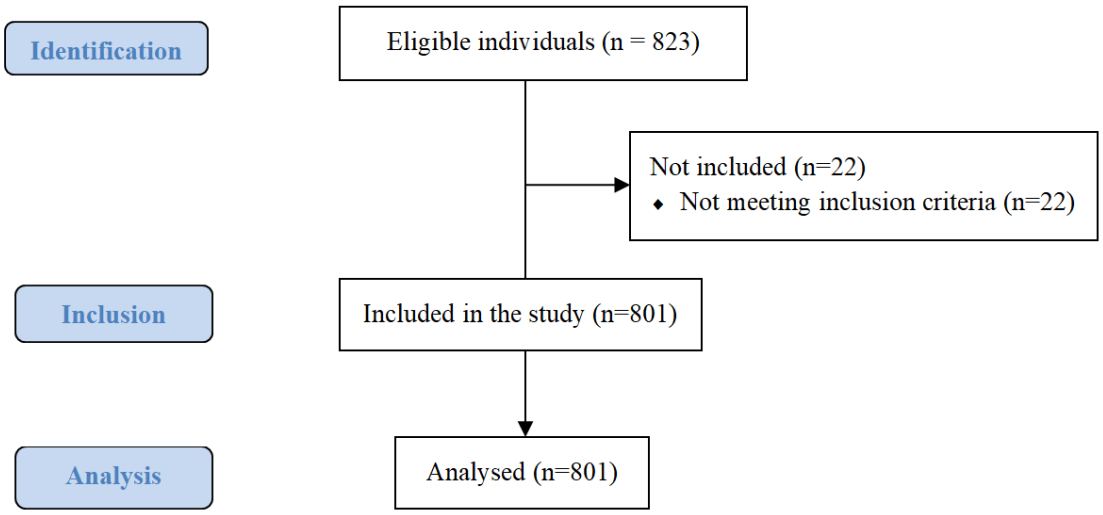
The Mann-Whitney test was used to compare differences between the sexes and between groups with and without TMD. The Kruskal-Wallis test was used to determine the existence of differences in mandibular movements among age groups, and Dunn's post hoc test was used for multiple comparisons. All data were expressed as median and interquartile range

(25^{th} – 75^{th} percentile). The level of significance was set at 5% ($p < 0.05$). The effect size between the interactions was verified by the partial eta squared (η_p^2). The interpretation was based on the values established by Cohen (21): no effect (less than $\eta_p^2 = 0.003$); small effect ($\eta_p^2 = 0.010$ to 0.039); intermediate effect ($\eta_p^2 = 0.06\,0$ to 0.110); and large effect (greater than $\eta_p^2 = 0.140$). All statistical analyses were performed using the SPSS program, version 20.0 (SPSS Inc., Chicago, USA).

Results

A total of 823 individuals were recruited, 22 of whom were excluded due to a history of facial trauma or surgery. Thus, 801 Brazilian men and women from five to 80 years of age participated in the study (Fig. 1). A total of 73.5% were diagnosed without TMD based on the SFAI. Among these individuals, the majority (54.5%) were female. Among the individuals diagnosed with TMD, 95.3% were female, of whom 65.5% belonged to the 20 to 39-year-old age group. (Table 1)

Figure 1 - Strobe low diagram



Source: Authors data.

Table 1 - Characteristics of the Brazilians – relative (%) and absolute (n) frequencies

	Without TMD 73.5% (n=589)		With TMD 26.5% (n=212)	
Age group	Female 54.5% n=321	Male 45.5% n=268	Female 95.3% n=202	Male 4.7% n=10
5 to 9	13.1% (n=42)	22.8% (n=61)	0.0% (n=0)	0.0% (n=0)
10 to 14	2.8% (n=9)	5.6% (n=15)	1.5% (n=3)	0.0% (n=0)
15 to 19	9.0% (n=29)	8.2% (n=22)	7.9% (n=16)	10.0% (n=1)
20 to 39	42.4% (n=136)	29.5% (n=79)	65.5% (n=133)	50.0% (n=5)
40 to 59	19.9% (n=64)	21.3% (n=57)	17.2% (n=35)	40.0% (n=4)
60 to 80	12.8% (n=41)	12.7% (n=34)	7.4% (n=15)	0.0% (n=0)

Source: Authors data.

The ICC for intra-evaluator reliability of maximum vertical mandibular movement (opening) was 0.98, and the SEM was 0.1. The ICC for inter-evaluator reliability was 0.97, and the SEM was also 0.1. For the lateral excursion, the ICC for intra- and inter-evaluator was ≥ 0.87, and the SEM was ≤ 0.2. (Table 2)

Table 2 - ICC and SEM for maximum opening (MO), right lateral excursion (RL) and left lateral excursion (LL) of the jaw

	Intra-evaluator						Inter-evaluator	
	Evaluator 1		Evaluator 2		Evaluator 3		Evaluator 1, 2 and 3	
	ICC	SEM	ICC	SEM	ICC	SEM	ICC	SEM
MO	0.98 (0.95-0.99)	0.1	0.98 (0.95-0.99)	0.1	0.98 (0.96-0.99)	0.1	0.97 (0.95-0.99)	0.1
RL	0.87 (0.69-0.96)	0.2	0.97 (0.92-0.99)	0	0.97 (0.94-0.99)	0	0.93 (0.86-0.98)	0.1
LL	0.88 (0.70-0.96)	0.2	0.91 (0.78-0.97)	0.1	0.93 (0.84-0.98)	0.1	0.87 (0.74-0.96)	0.1

Source: Authors data.

Table 3 displays the values obtained for the individuals with and without TMD. Independently of sex, both maximum opening and lateral excursion of the jaw diminished significantly in individuals with TMD, with a large effect size in women and an intermediate effect size in men. Another important finding was the fact that the ratio between opening and lateral excursion [opening / (right lateral excursion + left lateral excursion / 2)] increased in the group with TMD in both genders, with a small effect size.

Table 3 - Mandibular movements in individuals without and with TMD (median and interquartile range)

		Without TMD	With TMD	P value	Effect Size
Opening	Fem	40.99 [39.22-45.83]	36.35 [32.14-39.12]	p<0.001*	0.28§
	Male	48.12 [43.87-50.09]	39.56 [36.35-41.08]	p<0.001*	0.07‡
Right lateral excursion	Fem	8.26 [7.10-9.54]	6.52 [5.29-7.68]	p<0.001*	0.14§
	Male	10.11 [8.79-10.91]	7.05 [4.48-8.36]	p<0.001*	0.07‡
Left lateral excursion	Fem	8.10 [6.94-9.56]	6.37 [5.22-7.57]	p<0.001*	0.15§
	Male	9.99 [8.36-10.84]	6.80 [4.79-7.42]	p<0.001*	0.06‡
Ratio	Fem	5.23 [4.56-5.95]	5.59 [4.81-6.45]	p=0.001*	0.02†
	Male	4.75 [4.43-5.38]	5.52 [5.29-6.33]	p=0.001*	0.04†

* P value < 0.05; † Small effect; ‡ Intermediate effect; § Large effect
Source: Authors data.

To facilitate data interpretation, the sample was divided into age groups denominated A, B, C, D, E, and F. Table 4 displays the median and interquartile range mandibular movements per gender and age group. Considering the mean of all ages, the range of motion differed between the sexes. Considering the age groups and sexes, we found few differences, especially between children and adults in relation to all movements and between elderly and adults in lateral movements. Such discrepancies were more frequent in the male sex.

Table 4 - Median and interquartile range of mandibular movements in Brazilians divided into age groups

	Female	Male	*P*-Value
Opening			
05 a 09 (A)	47.39 [43.75-48.79]	46.09 [43.27-48.67]	0.59
10 a 14 (B)	45.26[42.07-51.46]	46.75[44.99-48.60]	0.48
15 a 19 (C)	45.37[41.30-50.13]	49.12[46.04-50.29]	0.03
20 a 39 (D)	43.05[40.61-47.36]	49.33[47.56-51.68]†	< 0.0001
40 a 59 (E)	41.65[40.13-47.01]	49.71[47.73-50.77]†	< 0.0001
60 a 80 (F)	41.14[40.01-46.98]†	48.36[44.57-49.56]	< 0.0001
Between Ages	**0,01**	**< 0.0001**	
Mean between ages	**43.02 [40.38-47.84]**	**48.64 [46.42-50.28]**	**< 0.0001**
Right lateral excursion			
05 a 09 (A)	8.60 [7.11-10.16]	9.20 [8.16-10.22]	0.25
10 a 14 (B)	8.58 [7.66-9.35]	10.90[10.35-11.25]†	0.003
15 a 19 (C)	8.46[6.75-9.76]	9.50[8.52-10.47]	0.09
20 a 39 (D)	9.29[8.43-10.41]	10.44[9.74-11.26]†	< 0.0001

	Female	Male	*P*-Value
Opening			
40 a 59 (E)	8.91[8.11-10.26]	10.62[10.14-11.46]†,‡	< 0.0001
60 a 80 (F)	9.37[8.10-10.08]	10.01[8.95-10.63]§	0.03
Between Ages	**0.29**	**< 0.0001**	
Mean between ages	**9.09 [8.11-10.18]**	**10.30 [9.37-11.07]**	**< 0.0001**
Left lateral excursion			
05 a 09 (A)	8.60 [7.66-9.52]	9.12 [7.57-10.28]	0.41
10 a 14 (B)	8.66[7.03-9.49]	10.69[9.33-10.95]	0.01
15 a 19 (C)	8.36[7.48-9.52]	10.15[8.58-10.88]	0.02
20 a 39 (D)	9.09 [8.15-10.24]	10.43[9.44-10.93]†	< 0.0001
40 a 59 (E)	9.04[7.60-10.08]	10.83[10.18-11.25]†	< 0.0001
60 a 80 (F)	9.31[8.20-10.41]	9.83[9.34-10.71]§	0.05
Between Ages	**0.22**	**< 0.0001**	
Mean between ages	**9.03 [7.93-10.01]**	**10.34 [9.28-10.92]**	**< 0.0001**

†#A / ‡#C / §#E
Source: Authors data

Discussion

This study aimed to evaluate jaw movements and the ratio between maximum jaw opening and mandibular lateral excursion in Brazilians with and without TMD, as well as compare genders and different age groups. The median values of maximum jaw opening and lateral excursion were lower in individuals with TMD, with an effect size from intermediate to large. The ratio between movements was significantly higher in the presence of TMD, with a small effect size, refuting part of the hypothesis of the present study. When Brazilians were divided into different age groups, median maximum opening and lateral excursion differed mainly between adults and younger age groups and among adults and the elderly, also with a difference between genders.

The reduction in mandibular range of motion was observed in the presence of TMD independently of sex, with a large effect size in women and intermediate in men. These results corroborate with findings described in other studies that have evaluated these same outcomes and also used digital calipers for the measurements and screening questionnaires for the assessment of TMD[8-11,22]. However, the present study was the first to use SFAI, whose accuracy

was recently examined in relation to the DC/TMD standard, with a sensitivity of 91.5% and specificity of 93.0% for the TMD. The cutoff point to identify individuals with TMD was determined as 12.5, with an area under the curve of 0.97 and a 95% confidence interval from 0.95 to 1.00[16]. These data show that the SFAI is a valid questionnaire to identify the presence of TMD, being of quick application and easy access for researchers and clinicians.

The ratio between opening and lateral excursion in Brazilians without TMD was 4.75 in men and 5.23 in women. This ratio was initially defined by some authors as 4:1 in healthy individuals[4], but was questioned later by other studies, which observed different values, 5.1:1 and 6:1 in the healthy population[5,9] - corroborating the results of the present study. It is important to emphasize that none of the studies that evaluated this variable had a sample size as robust as the one in the present study, with 91 and 242 participants, respectively[5,9]. Thus, according to our results, 1 mm of lateral excursion would be expected for every 4.75 mm and 5.23 mm of jaw opening in men and women, respectively, contesting the initially proposed values of 4 mm[4].

Moreover, in Brazilians diagnosed with TMD, the initial hypothesis was based on the proportional impairment of both movements in TMD, maintaining the ratio between them. However, despite the small effect size, an increase in the ratio was observed in this population (approximately 5.5), indicating a greater impairment of the lateral excursion compared to the mandibular opening. Differently, the study by Türp et al.[9] observed values in the population with TMD close to those of healthy individuals, but when the sample was divided by gender, men showed an increased ratio in relation to the healthy group, corroborating the results of the present study. Such discrepancies could be explained by the sample size and the exclusion of individuals diagnosed with disc displacement without reduction in the mentioned study[9], a condition that can affect the range of lateral movements, influencing the ratio[4].

The relationship between opening and lateral excursion brings essential data to the evaluator once it has already been demonstrated that lateral movements better estimate condyle translation than mandibular opening movement[6]. This indicates that a reduction in the opening may be more related to extra-articular dysfunctions, while reduced horizontal movements may indicate intra-articular impairment[4]. When analyzing the proposed fraction between opening and lateral excursion, a reduction in the final value would occur if the numerator (opening) were reduced. However, if there was a more significant decrease in the denominator (lateral excursion), we could expect an increase in the ratio between opening and lateral excursion, which happened in the present study. In order to observe the stability of this ratio in both groups,

a proportional change in both values of mandibular range of motion would be necessary, which did not occur with the evaluated sample. Thus, we can assume that the increase in the ratio with the presence of TMD indicates greater impairment in function, as mandibular movements (mainly lateral excursion) and functionality seem to be extremely associated[8,23].

Regarding the differences observed between age groups, some studies have demonstrated that mandibular range of motion seems to increase from birth to adolescence, likely due to anatomic changes, maturation of the central nervous system and the occlusion, and other factors[10,24,25]. This was mainly found in the male sex in the present study, as significant differences in maximum opening and lateral excursion values were found in the comparison of children and adults, with larger ranges of motion among the adults, as described in the study by Cattoni and Fernandes[24]. However, this difference was little observed in the female sex, likely due to the greater frequency of TMD in this group. We also found no reduction in range of motion with the increase in age after the maturation of the body, as some studies suggest[26,27], only in lateral excursions when comparing elderly and adult men. This divergence may be explained by the use of instruments other than digital calipers to measure range of motion[26,27] and samples of different nationalities in comparison to the sample in the present study. Thus, one should also consider the influence of the morphological characteristics of each population, such as jaw length and height of the individual[28,29].

In the present study, a complete assessment of jaw movements was performed in Brazilians with and without TMD of different sexes and ages, which offers a broad view of the characteristics of TMJ mobility in a diversified population. Different factors are known to influence the measurement of mandibular range of motion, such as the use of different instruments (ruler, imaging exams, digital calipers, analog calipers), the inclusion or non-inclusion of overbite in the measurement of jaw opening, and measurement of maximum opening without pain, maximum unassisted jaw opening, or maximum assisted jaw opening[17]. Therefore, a reliability test was performed, which ensured the reproducibility and quality of the measurements. For all measurements of mandibular range of motion, digital calipers, which are well-accepted and widely used in the literature[12,25,30], proved to be highly reliable and with a low measurement error.

Conclusion

The results in the population studied suggest that mandibular range of motion is an important variable to consider in the assessment of individuals with TMD as well as the

evaluation of the effects of a therapeutic program, as these measurements differed significantly in comparison to those in asymptomatic individuals. The ratio between maximum jaw opening and lateral excursion is a complementary outcome that could be used by clinicians and researchers in combination with other clinical findings to assess functioning. We believe that studies with a higher sample power can lead to a novel classification using this ratio for the evaluation of individuals with limited jaw movements. Therefore, clinicians could analyze whether there is impairment in lateral movements or in the opening and what measures need to be improved during treatment. Future studies should include the measurement of protrusion and involve more homogeneous age groups of individuals with different subtypes of TMD.

Funding

This work was supported by *Universidade Nove de Julho* (UNINOVE) and *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES [Coordination for the Advancement of Higher Education Personnel] process number: 88882.366706/2019-01; 88887.612390/2021-00; 88887.643023/2021-00; 88887.643024/2021-00).

Declaration of interest statement

The authors report no conflict of interest.

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