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CLINICAL RESEARCH

Relationship between sleep bruxism and masticatory performance in healthy adults: A cross-sectional study

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ABSTRACT

Statement of problem. Bruxism may have positive clinical consequences, but whether it contributes to masticatory function remains unclear.

Purpose. The purpose of this clinical study was to clarify the relationship between sleep bruxism and masticatory performance in young adults with healthy dentitions and to determine the roles of occlusal force, dental occlusion, temporomandibular disorders (TMDs), and jaw symptoms.

Material and methods. Ninety-seven dental students with healthy dentitions participated in this cross-sectional study (median age, 21.9 years; 84 women). Sleep bruxism was assessed at the dental level as the relative peeled area of a BruxChecker worn for 3 nights. Occlusal contact area and maximum occlusal force were measured using silicone transillumination and the Innobyte system. Frequencies of bruxism-related jaw symptoms and TMD were determined using the BruxScreen and diagnostic criteria for TMD protocols. Masticatory performance was assessed by masticating bagged silicone for 20 cycles and calculating the masticatory performance index as the percentage of silicone in weight that passed a 3.15-mm sieve. Bivariate and multiple linear regression analyses were performed, followed by moderated mediation modeling that considered the relative peeled area as a predictor, masticatory performance index as an outcome, and sex as a covariate (α=.05).

Results. Relative peeled area showed a bivariate positive correlation with the masticatory performance index (P<.05), but this was not significant in the stepwise multiple regression model (P>.05). Moderated mediation analysis revealed the relative peeled area exerted a positive indirect effect on masticatory performance via the occlusal force and occlusal contact area, which functioned as serial mediators. This indirect effect was not significant in participants with TMD pain and frequent jaw symptoms (P>.05).

Conclusions. Sleep bruxism may enhance masticatory performance in healthy dentate adults without TMD pain or bruxism-related jaw symptoms. This effect is primarily mediated by an increase in occlusal force and an enlargement of the occlusal contact area. (J Prosthet Dent xxxx;xxx:xxx-xxx)

Bruxism refers to different jaw muscle activities during sleep or wakefulness characterized by teeth clenching or grinding, bracing or thrusting of the mandible, or a combination of these features.[1] Assessment can grade bruxism as “possible” by self-report, “probable” by clinical examination, and “definite” by polysomnography.[2] Recently, a standardized tool for the assessment of bruxism and its short version, BruxScreen, have been published; the BruxChecker has also been proposed as a valid instrument for assessing sleep bruxism quantitatively at the dental level.[3–5]

Bruxism could be harmless, have negative consequences, or have positive clinical consequences.[6] For example, bruxism can increase masticatory muscle strength and

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Clinical Implications

In the absence of symptoms in the masticatory system, sleep bruxism may increase occlusal force at the dental level, which, in turn, may lead to a wider occlusal contact area and improved masticatory performance. This might reflect another positive health benefit of sleep bruxism.

enlarge the area of occlusal contact.[7–9] Key predictors of masticatory performance are the maximum occlusal force (MOF) and the occlusal contact area (OCA), suggesting a role for bruxism in enhancing masticatory performance.[10–12] The authors are unaware of an association being observed between masticatory performance and bruxism or dental wear in either adults or children[8,13–15]; other research has reported a positive relationship in children and adolescents.[16] Differences in the population studied, such as the presence of temporomandibular disorders (TMDs) or nonpain muscle symptoms, could explain these discrepancies.[17,18]

Associations between 2 variables in observational studies do not necessarily imply a causal relationship. However, when randomization is not feasible, statistical approaches can strengthen the basis for causal inference, such multivariable regression models, quantitative assessment of systematic bias, and conditional process analysis.[19–21] Conditional process analysis seeks to determine how and when a relationship occurs by elucidating what parameters mediate and moderate the possible causal relationship.[20]

This study aimed to clarify the relationship between sleep bruxism and masticatory performance in young adults with a healthy dentition. It also aimed to determine whether occlusal force and OCA function as mediators and whether TMD pain, TMD disk displacement, or bruxism-related jaw symptoms function as moderators in this relationship. The null hypothesis was that sleep bruxism would not be related to masticatory performance.

MATERIAL AND METHODS

A cross-sectional observational study was performed between November 2023 and March 2024 at the University of Barcelona dental school. One hundred and nine third year dental students were invited to participate if they were aged between 18 and 45 years, had a healthy dentition of at least 24 natural teeth without severe malocclusion, were not taking sedation medication, did not have chronic disease, and were not undergoing active orthodontic treatment. Participants who slept with minimum interruption or who did not use the BruxChecker for 3 nights were excluded from the sleep bruxism test. Most had participated in previous investigations.[5,22]

The local Ethics Committee approved the protocol (Ref. 25/2023), and all participants signed a written informed consent form. All procedures were conducted according to the principles of the Helsinki Declaration and reporting follows the OHStat guidelines.[23]

Participants were interviewed to collect data on sex, age, history of orthodontic treatment, risk of erosive tooth wear (medical history of gastric reflux, eating disorders, hyposalivation, or excessive acid intake), and excessive coffee consumption.[24] They were also asked to complete the Oral Behavior Checklist (OBC),[25] the Perceived Stress Scale (PSS),[26] and the Generalized Anxiety Disorder 7-item (GAD-7) scale.[27] The mean score for the OBS and the sum scores for the PSS and GAD-7 were calculated.

Clinical examination was performed to measure the vertical overlap (using calipers) and the body weight and height (to calculate body mass index). The questionnaire and examination components of the Diagnostic Criteria for TMD were applied to determine whether participants had TMD pain (myalgia, arthralgia, related headache) or TMD disk displacement.[28,29] The upper arm circumference and the triceps skinfold thickness were measured to calculate the percentage muscle mass.[22] Handgrip strength was measured using a hand-held grip dynamometer (EH-101; Camry) 3 times in each hand, with the highest value recorded.[22] Bilateral MOF was determined using an occlusal force measurement device (Innobyte; Kube Innovation) according to the manufacturer's instructions, and the average of the highest 2 values from 3 measurements was recorded.[22]

A single examiner (M.U.-B.) conducted the interview and clinical assessment for the BruxScreen according to published instructions.[4,5] The answer to the question "How often do you grind your teeth during sleep?" was dichotomized as "no sleep grinding" (never) or "self-report of sleep grinding" (sometimes, regularly, often, or always). Regarding bruxism-related jaw symptoms, the sum score was calculated using a 5-point ordinal scale (0, never; 1, sometimes; 2, regularly; 3, often; 4, always) for the 26 questions. The examiner determined the presence or absence of masseter muscle hypertrophy and the presence or absence of lip-, cheek-, and tongue-indentations, traumatic lesions of the tongue, and tori, recording the number of positive signs of nondental tissues. Occlusal or incisal wear per sextant, plus palatal wear in sextant 2, were assessed and the sum of all 7 scores was considered to indicate tooth wear. The presence of the 20 clinical signs according to the Tooth Wear Evaluation System (TWES) 2.0 was evaluated and recorded as the percentage of clinical signs of chemical or mechanical tooth wear.[30,31]

Table 1. Test-retest reliability of main variables

Variable	N	ICC (95%CI)	Weighted kappa (95%CI)	Cohen kappa (95%CI)	*P*
Bruxism (BruxChecker or BruxScreen)					
Relative peeled area BruxChecker (%)[a]	81	0.929 (0.891, 0.954)			<.001 †
Perforation in BruxChecker (no, yes)[a]	81			0.777 (0.640, 0.914)	<.001
Self-report of sleep grinding (no, yes)	15			1.000 (1.000, 1.000)	<.001
Sum score of jaw symptoms	15		0.301 (0.024, 0.578)		.044
Hypertrophy of masseter (no, yes)	15			0.595 (0.116, 1.000)	.012
Number of signs in non-dental tissues	15		0.412 (0.000, 0.829)		.027
Sum score of tooth wear per sextant	15		0.590 (0.316, 0.864)		<.001
Dental Occlusion					
Vertical overlap (mm)	15	0.865 (0.653, 0.952)			<.001 †
Occlusal contact area (mm^2)	15	0.972 (0.881, 0.992)			<.001 †
Force					
Handgrip strength (kg)[b]	100	0.979 (0.968, 0.986)			<.001 ‡
Maximum occlusal force (N)[b]	99	0.903 (0.851, 0.936)			<.001 ‡
Tooth wear					
Signs of chemical origin of tooth wear (%)	15	0.973 (0.924,0.991)			<.001 †
Signs of mechanical origin of tooth wear (%)	15	0.526 (0.042, 0.811)			.006 †
Temporomandibular disorders					
TMD pain (no, yes)	15			1.000 (1.000, 1.000)	<.001
TMD disk displacement (no, yes)	15			0.762 (0.324, 1.000)	.002
Masticatory function					
Masticatory performance index (%)	15	0.786 (0.040, 0.943)			<.001 †
Median particle size (mm^2)	15	0.866 (0.042, 0.969)			<.001 †

ICC, 2-way random, absolute agreement for † single or ‡ average measurements.
CI, confidence interval; ICC, intraclass correlation coefficient.

[a] reported in Ustrell-Barral et al.[5]

[b] reported in Ustrell-Barral et al.[22]

The OCA at the maximum intercuspation position was determined using silicone transillumination.[5,32] A polyvinyl siloxane occlusal registration material (Occlufast Rock; Zhermack SpA) was applied to the mandibular teeth and participants were asked to occlude at the intercuspation position as hard as they could for 1 minute. The occlusal registration was removed, trimmed, scanned, and analyzed. Occlusal contact was considered present for an interocclusal distance of ≤200 μm and the surface area was measured.[12]

The BruxChecker comprises a 0.1-mm-thick transparent plate with an external surface painted red (Brux checker; Scheu-Dental) that is adapted and trimmed to a maxillary gypsum cast with a pressure molding machine (Biostar VII; SCHEU DENTAL GmbH).[33] All participants were instructed to wear the BruxChecker during sleep for 3 consecutive nights according to the manufacturer's instructions. After the third night, each BruxChecker was scanned by transillumination, and the peeled area was measured.[5] Each maxillary gypsum cast had been scanned previously, and the occlusal surface area was measured. The percentage peeled area on the BruxChecker, with respect to the total occlusal surface area, was calculated to obtain the BruxChecker relative peeled area (BC-RPA). Perforation of the BruxChecker was assessed visually by direct inspection after 3 nights of wear.

The masticatory assay comprised 5 trials of masticating a latex bag containing 2 g of silicone particles (Optosil P Plus; Kulzer GmbH, Zetalabor; Zhermack SpA) for 20 masticatory cycles.[34–36] The degree of comminution of silicone was evaluated by sieving the particles under vibration in a series of 8 sieves with gaps ranging in size from 0.25 to 5.6 mm. The cumulative weight distribution of the sieved contents was determined and the Rosin–Rammler equation was used to estimate the median particle size (MPS).[37] The masticatory performance index (MPI) was calculated as the percentage of masticated silicone by weight that passed through a 3.15-mm sieve,[38] such that a low MPS corresponded to a high MPI and good masticatory performance.

The sample size had been calculated to include at least 15 participants per predictor in the regression model.[39] According to the literature, up to 5 predictors in this model were estimated, suggesting the need for a minimal sample size of 75. To evaluate the reliability of the main parameters, the masticatory tests and data collection were repeated after 2 weeks in 15 participants (chosen by convenience). The reliability of quantitative, ordinal, and dichotomous variables was assessed by the intraclass correlation coefficient (ICC), weighed kappa, and Cohen kappa. The ICC for the MPI, MPS, and OCA were 0.786, 0.866, and 0.972; the weighed and Cohen

Table 2. Participant characteristics by sex

Characteristic	N	Total	Women (n=84)	Men (n=13)	*P*
Bruxism (BruxChecker or BruxScreen)					
Relative peeled area BruxChecker (%), mean (95%CI)	83	10.5 (9.5, 11.5)	10.3 (9.2, 11.4)	12.3 (8.8, 15.8)	.202 ‡
Perforation in BruxChecker, n (%)	83	38 (45.8%)	32 (43.8%)	6 (60.0%)	.336 §
Self-report of sleep grinding (BruxScreen), n (%)	97	21 (21.6%)	18 (21.4%)	3 (23.1%)	1.000 §
Sum score of jaw symptoms, median (IQR)	97	2.0 (0.0, 6.0)	2.0 (0.0, 7.5)	1.0 (0.0, 5.0)	.974 †
Hypertrophy of masseter (BruxScreen), n (%)	97	23 (23.7%)	17 (20.2%)	6 (46.2%)	.073 §
Number of signs in non-dental tissues, median (IQR)	97	2.0 (2.0, 2.0)	2.0 (2.0, 2.0)	1.0 (2.0, 2.5)	.293 †
Sum score of tooth wear per sextant, median (IQR)	97	5.0 (2.5, 6.0)	4.5 (2.0, 6.0)	6.0 (4.0, 6.5)	.064 †
Demographic/General/anthropometric/nutrition					
Age (years), median (IQR)	97	21.9 (20.4, 23.8)	21.9 (20.4, 23.7)	22.6 (21.0, 25.5)	.242 †
Weight (kg), median (IQR)	95	61.3 (56.7, 69.0)	60.5 (56.6, 66.4)	78.0 (69.9, 85.7)	<.001 †
Height (m), median (IQR)	95	1.67 (1.61, 1.72)	1.65 (1.61, 1.69)	1.78 (1.74, 1.84)	<.001 †
Body mass index (kg/m^2), mean (95%CI)	95	22.8 (22.2, 23.5)	22.6 (21.9, 23.4)	24.4 (23.0, 25.8)	.072 ‡
Percentage of muscular mass (%), mean (95%CI)	97	62.2 (60.3, 64.1)	61.2 (59.2, 63.2)	68.8 (64.6, 73.1)	.006 ‡
Dental Occlusion					
History of orthodontic treatment, n (%)	96	66 (68.8%)	60 (72.3%)	6 (46.2%)	.103 §
Vertical overlap (mm), median (IQR)	97	2.7 (2.0, 3.9)	2.3 (2.0, 3.8)	3.0 (3.0, 4.0)	.112 †
Occlusal contact area (mm^2), mean (95%CI)	97	91.2 (83.3, 99.1)	89.1 (80.8, 97.4)	105.1 (78.2, 132)	.172 ‡
Occlusal surface area (mm^2), mean (95%CI)	84	859 (843, 876)	849 (833, 865)	934 (868, 1000)	<.001 ‡
Force					
Handgrip strength (kg), mean (95%CI)	97	32.6 (31.0, 34.2)	30.4 (29.2, 31.5)	47.4 (43.0, 51.8)	<.001 ‡
Maximum occlusal force (N), mean (95%CI)	96	700 (668, 731)	681 (650, 712)	818 (706, 931)	.002 ‡
Habits and psychological aspects					
Risk of erosive tooth wear, n (%)	97	14 (14.4%)	12 (14.3%)	2 (15.4%)	1.000 §
Excessive Coffee consumption, n (%)	97	55 (56.7%)	51 (60.7%)	4 (30.8%)	.069 §
Mean Score of Oral Behavior Checklist, mean (95%CI)	97	1.02 (0.94, 1.10)	1.02 (0.93, 1.11)	1.01 (0.78, 1.24)	.897 ‡
Sum Score Perceived Stress Scale, median (IQR)	93	24.0 (18.0, 30.5)	26.0 (18.0, 31.8)	18.0 (7.5, 25.5)	.016 †
Sum Score of GAD scale for Anxiety, median (IQR)	91	5.0 (3.0, 10.0)	6.0 (3.0, 11.0)	5.0 (3.0, 6.0)	.353 †
Tooth wear					
Signs of chemical origin of tooth wear (%), median (IQR)	97	13.0 (0.0, 14.0)	13.0 (0.0, 14.0)	11.1 (0.00, 19.5)	.925 †
Signs of mechanical origin of tooth wear (%), median (IQR)	97	57.0 (43.0, 71.0)	57.0 (43.0, 71.0)	57.0 (49.5, 71.4)	.478 †
Temporomandibular disorders					
TMD pain, n (%)	97	19 (19.6%)	16 (19.0%)	3 (23.1%)	.715 §
TMD Disk displacement, n (%)	97	13 (13.4%)	11 (13.1%)	2 (15.4%)	.685 §
Masticatory function					
Masticatory performance index (%), mean (95%CI)	97	36.8 (31.9, 41.6)	33.2 (28.3, 38.1)	60.0 (46.6, 73.4)	<.001 ‡
Median particle size (mm^2), median (IQR)	97	3.49 (2.87, 5.25)	3.60 (3.01, 5.52)	2.58 (2.43, 3.04)	<.001 †

CI, confidence interval; IQR interquartile range; TMD, temporomandibular disorder. † Mann–Whitney U test, ‡ Student *t* test, § chi-squared test (Fisher Exact Test)

kappa scores of the BruxScreen and TMD parameters ranged from fair (0.301) to excellent (1.000) (Table 1). Given a large sample size, the ICC values for the BC-RPA and MOF were 0.929 and 0.903.[5,22]

The Kolmogorov–Smirnov test confirmed the normality of distributions for the main variables, except the MPS. The student *t* test, Mann–Whitney *U* test, and chi-squared test (or Fisher Exact Test, when appropriate) were used to compare participant characteristics by sex. A significant quadratic correlation (r^2=0.977) was observed between the MPI and MPS (Supplemental Figure 1, available online). Given that MPI values were normally distributed, they were used as the outcome measure. Bivariate associations between variables and the MPI were evaluated using the Pearson or Spearman correlation. A multiple linear regression model was performed using a stepwise backward method to examine whether variables significantly associated with MPI in the bivariate analyses contributed meaningfully to explaining the variance in MPI. Underlying assumptions of the regression model were evaluated by visual inspection of the residuals with the P–P plot and by plotting them against the predicted outcome values, using the Durbin–Watson test, and assessing variance inflation factors (VIF). Sample selection bias was evaluated by comparing participants who completed the BruxChecker test with those who did not to determine whether the groups differed in primary and bruxism-related parameters (using the Mann–Whitney U test and chi-squared test) and whether the correlation between MPI and MOF and OCA varied between groups.

A moderated mediation analysis was conducted using Hayes PROCESS macro for the statistical software program (IBM SPSS Statistics, v4.2; IBM Corp).[20] First, the moderation effect of the quantitative variable "jaw symptoms" was tested on the relation between BC-RPA and MPI using the Johnson–Neyman technique (Model 1). A serial mediation model (Model 6) was also constructed to assess the role of MOF and OCA as mediators between BC-RPA and MPI, adjusted by sex. Finally, TMD pain, TMD disk displacement, and jaw symptoms were included in each moderated mediation model to test whether they acted as moderators (Model 85). Bootstrapping with 5000 repetitions and the heteroscedasticity consistent standard error of Caribari-Neto (HC4) were used to ensure normality and homoscedasticity. All analyses were performed with a statistical software program (IBM SPSS Statistics, v29; IBM Corp) (α=.05).

RESULTS

Among the 109 dental students invited to participate, 3 declined the invitation, 7 did not meet the inclusion criteria, and 2 were excluded because they failed to comminute any pieces during the masticatory assay. Another 13 participants did not participate in the BruxChecker tests: 2 slept with interruptions, 5 declined the invitation, and 6 were unavailable; finally, 1 participant did not wear the BruxChecker for all 3 nights and was excluded from the BruxChecker analysis. In addition, 1 participant did not perform the MOF test. Therefore, 97 individuals were included, of whom 83 performed the BruxChecker test and 82 provided all required data.

The 97 included participants had a median age of 21.9 years (range 19.9 to 40.4) and 84 (86.6%) were women (Table 2). Men had higher body weight, height, muscle mass percentage, OCA, handgrip strength, MOF, stress perception, and MPI compared with women, but no sex differences were observed in any aspect of bruxism.

Table 3 shows the bivariate correlations of the main study variables. MPI correlated positively with age, height, vertical overlap, OCA, occlusal surface area, hand grip strength, MOF, and several aspects of bruxism (including BC-RPA, self-reported sleep grinding, masseter hypertrophy, and tooth wear per sextant). Men and participants who had not received orthodontic treatment had significantly higher masticatory performance than women or those who had received orthodontic treatment (P<.05).

Backward multiple regression analysis showed that MOF, history of orthodontic treatment, occlusal surface area, and OCA most directly affected the MPI (Table 4). These 4 variables accounted for 39.5% of the variation in masticatory performance (R_a^2=0.395; P<.001). The Durbin–Watson statistic was 2.247, suggesting the independence of residuals. Visual inspection of the scatterplot between unstandardized predicted values and studentized residuals confirmed the assumption of

Table 3. Bivariate correlation analyses for bruxism-related parameters

Characteristic	N	Masticatory Performance Index (%)	Maximum occlusal force (N)	Occlusal contact area (mm^2)	Relative Peeled area Bruxchecker (%)
Bruxism (BruxChecker or BruxScreen)					
Relative peeled area BruxChecker (%)[a]	83	0.349***	0.297**	0.396***	
Perforation in BruxChecker, (0=no; 1=yes)	83	0.034	−0.020	−0.103	0.558***
Self-report of sleep grinding, (0=no; 1=yes)	97	0.243*	0.215*	0.210*	0.417***
Sum score of jaw symptoms	97	−0.117	−0.018	−0.123	0.080
Hypertrophy of masseter, (0=no; 1=yes)	97	0.235*	0.411***	0.302**	0.197
Number of signs in non-dental tissues	97	0.057	0.209*	0.120	−0.020
Sum score of tooth wear per sextant	97	0.303**	0.230*	0.212*	0.391***
Demographic/General/anthropometric/nutrition					
Sex (0=women; 1=men)	97	0.379***	0.261**	0.139	0.133
Age (years)	97	0.245*	0.100	0.367***	0.079
Weight (kg)	95	0.183	0.074	−0.012	−0.014
Height (m)	95	0.216*	0.109	0.156	0.227*
Body mass index (kg/m^2)[a]	95	0.095	0.065	−0.101	−0.138
Percentage of muscular mass (%)[a]	97	0.184	0.184	0.189	0.112
Dental Occlusion					
History of orthodontic treatment, (0=no; 1=yes)	96	−0.397***	−0.149	−0.123	−0.191
Vertical overlap (mm)	97	0.355***	0.370***	0.339***	0.111
Occlusal contact area (mm^2)[a]	97	0.460***	0.491***		0.396***
Occlusal surface area (mm^2)[a]	84	0.297**	0.022	0.163	0.047
Force					
Handgrip strength (kg)[a]	97	0.366***	0.348***	0.181	0.199*
Maximum occlusal force (N)[a]	96	0.453***		0.491***	0.297**
Habits and psychological aspects					
Risk of erosive tooth wear, (0=no; 1=yes)	97	−0.007	−0.031	−0.059	0.143
Excessive coffee consumption, (0=no; 1=yes)	97	−0.001	0.104	0.076	−0.002
Mean Score of Oral Behavior Checklist	97	−0.075	0.041	0.017	0.185
Sum Score Perceived Stress Scale	93	−0.155	−0.159	−0.003	0.139
Sum Score of GAD scale for Anxiety	91	−0.122	0.000	0.002	0.058
Tooth wear					
Signs of chemical origin of tooth wear (%)	97	−0.061	0.030	−0.066	0.063
Signs of mechanical origin of tooth wear (%)	97	0.185	0.155	0.051	0.145
Temporomandibular disorders					
TMD pain, (0=no; 1=yes)	97	0.153	0.151	0.028	0.019
TMD Disk displacement, (0=no; 1=yes)	97	−0.182	−0.224*	−0.263**	0.080

*** P≤.001; ** P≤.01; * P≤.05. Spearman correlation coefficient, except [a] Pearson correlation coefficient. TMD, temporomandibular disorder.

Table 4. Backward stepwise regression model of factors related to masticatory performance index (%)

Variables Included	Unstandardized B (95%CI)	SE B	β	*P*
(Constant)	−60.10 (−113, −7.59)	26.4		.025
Maximum occlusal force (N)	0.045 (0.014, 0.076)	0.016	0.286	.005
History of orthodontic treatment (0=no; 1=yes)	−15.45 (−24.5, −6.4)	4.546	−0.298	.001
Occlusal surface area (mm^2)	0.073 (0.017, 0.129)	0.028	0.228	.011
Occlusal contact area (mm^2)	0.150 (0.026, 0.274)	0.062	0.244	.018

Note. R_a^2=0.395; F=14.25; *P*<.001). Selection criteria PIN(.05) POUT(.10), and method used for missing values pairwise.

linearity and homoscedasticity. VIF values were 1.34 and 1.37 for MOF and OCA, indicating no perfect multicollinearity. Comparing individuals who did and did not participate in the BruxChecker test, no significant differences in any parameter except for age (*P*<.001; Mann–Whitney *U* test) and a similar correlation between the MPI and both the MOF and OCA was observed between groups (Supplemental Figs. 2, 3, available online).

The Johnson–Neyman technique produced a moderated jaw symptom value of 7.5, indicating that the BC-RPA was significantly associated with MPI only in individuals with a jaw symptom sum score less than 7.5. Mediation analysis revealed that the BC-RPA exerted a positive indirect effect on the MPI via the MOF and OCA, which acted as serial multiple mediators (Fig. 1, Table 5). The total unstandardized effect, adjusted by sex, was 1.61 (95% confidence interval, 0.58 to 2.63; *P*=.003); thus, for each 1% increase in the BruxChecker peeled area, an average increase of 1.6% in the MPI would be expected.

The conditional process analysis revealed that the direct and indirect effects of the BC-RPA on the MPI were not significantly moderated by TMD pain, TMD disk displacement, or jaw symptoms when adjusted by sex (*P*>.05) (Figs. 2A-C and 3A-C). However, most indirect effects of the BC-RPA on the MPI were positive and significant in the groups without TMD pain and no or few jaw symptoms (*P*<.05), while they were statistically similar in the group with pain or frequent jaw symptoms (*P*>.05) (Fig. 2A, 2C). The presence of TMJ disk displacement did not moderate the relationship between BC-RPA and MPI (Figs. 2B, 3B).

DISCUSSION

This study revealed that sleep bruxism assessed at the dental level may improve masticatory performance among healthy individuals with a natural dentition. This effect was found to be mainly mediated through the occlusal force and the OCA. Therefore, the null hypothesis that sleep bruxism was not related to masticatory performance was rejected. However, sleep bruxism did not seem to affect the masticatory performance in

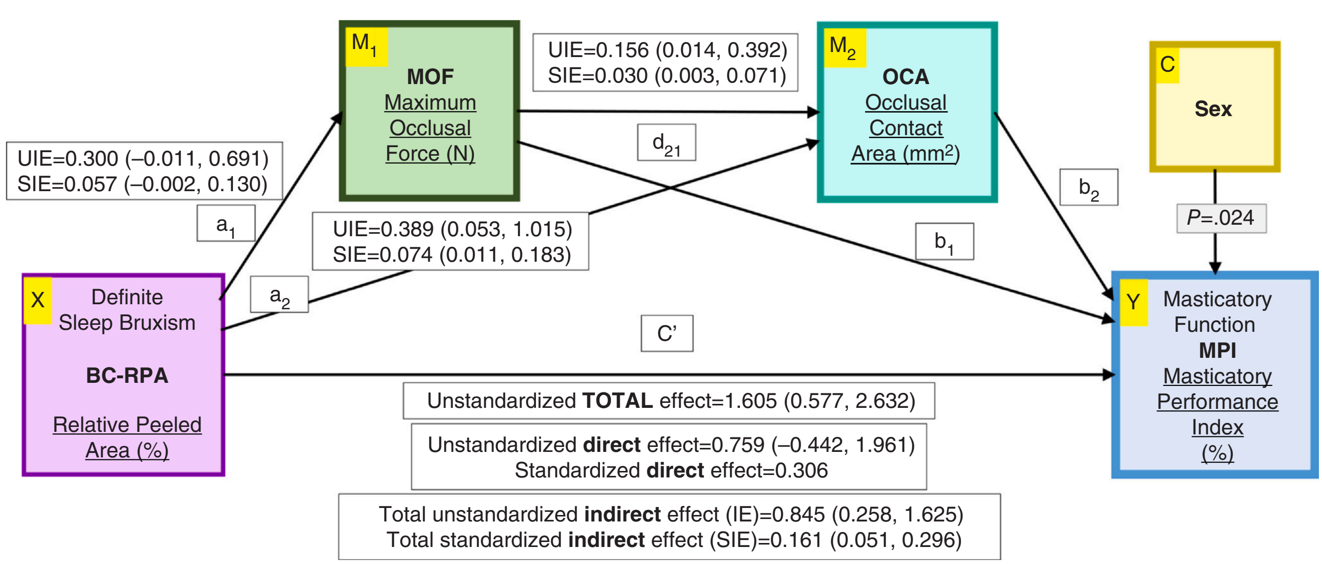

Figure 1. Serial multiple mediator model of relation between BruxChecker relative peeled area and masticatory performance index, adjusted by sex. Serial multiple mediator model with maximum occlusal force (M1) and occlusal contact area (M2) as mediators in relation between relative peeled area of BruxChecker (X%) and masticatory performance index (Y%) adjusted by sex (C) as covariate. Values show unstandardized or standardized (SIE) indirect (UIE and SIE) and direct (UDE and SDE) effects. Model 6: n=82; bootstrap 95% CIs in parentheses. CI, confidence interval; SB, sleep bruxism; TMD, temporomandibular disorder.

Table 5. Serial multiple mediator model for maximum occlusal force and occlusal contact area in the relationship between relative peeled area and masticatory performance index, adjusted by sex

Antecedent	M_1 (Maximum occlusal force, N)				M_2 (Occlusal contact area, mm^2)				Y (Masticatory performance index, %)			
		Coefficient	SE (HC4)	P		Coefficient	SE (HC4)	P		Coefficient	SE (HC4)	P
Relative peeled area (%)	a_1	8.75	3.84	.025	a_2	2.30	1.001	.024	c′	0.759	0.603	.212
Maximum occlusal force (N)					d_{21}	0.11	0.030	<.001	b_1	0.034	0.016	.038
Occlusal contact area (mm^2)									b_2	0.169	0.073	.023
Sex (0=women; 1=men)		98.6	68.9	.156		1.19	17.2	.945		16.5	8.44	.054
Constant		589.7	40.9	<.001		−8.47	19.8	.667		−13.1	10.2	.203
	R^2=0.133				R^2=0.311				R^2=0.351			
	F-HC4 (2, 79)=3.9. P=.0249				F-HC4 (3, 78)=7.7. P=.0001				F-HC4 (4, 77)=12.4. P<.0001			

Regression coefficients, standard errors, and model summary information for the serial multiple mediator model of maximum occlusal force and occlusal contact area in the relationship between relative peeled area and masticatory performance index, adjusted by sex.

M, mediator; SE(HC4), standard error of Caribari-Neto.

individuals with muscular TMD pain, articular TMD pain, or frequent bruxism-related jaw symptoms.

The positive association between sleep bruxism and masticatory performance has been reported previously[16] when the presence of sleep bruxism was confirmed by parental report of grinding sounds and the presence of tooth wear. The absence of a relationship between sleep bruxism and masticatory performance in individuals with TMD pain or bruxism-related jaw symptoms has also been reported in adult bruxers with transient jaw muscle pain in the morning or muscle fatigue on awakening.[13,14] The present results suggested that the discrepancies in these studies could reflect the populations studied.

Finding an association in cross-sectional research does not imply a direct cause-effect relationship. However, several arguments support the finding that sleep bruxism improves masticatory performance. First, quantitative bias analysis suggested a low probability of information bias, selection bias, or confounding. The main parameters were also measured using instruments that provide objective and quantitative results, thereby offering excellent reliability. In addition, data on masticatory performance were comparable with those in other cross-sectional studies with similar populations.[12,35,36] The inclusion of dental students facilitated the accuracy and reliability of the data collected. The bias analysis also suggested a low probability of selection bias because of the high participation rate and the similar results (except age) in a subsample of 14 individuals who did not participate in the BruxChecker test. However, the age imbalance should have little impact on the results of this homogeneous cohort. Sex was also included as a covariate in the moderation mediation models to control for confounding. All assumptions of linear regression models were met, including linearity, homoscedasticity, independence of errors, normality of residuals, and the absence of multicollinearity. The mediation analysis also confirmed that occlusal force and OCA lie on the causal pathway between sleep bruxism and masticatory performance, explaining the mechanism of action and reinforcing the assumption of causality. Finally, there is biological plausibility for a causal relationship between sleep bruxism and masticatory performance in terms of strength, consistency, temporality, and gradient.

Bruxism has been reported to be associated with negative consequences such as TMD related pain, jaw symptoms, and fractures and wear of both teeth and prostheses.[6,40] However, bruxism has also been associated with positive health effects, such as alleviating emotional stress, preventing airway collapse, increasing salivary flow, and improving cognitive function.[6,41] The authors propose that enhanced masticatory performance can be added to this list of the potentially positive

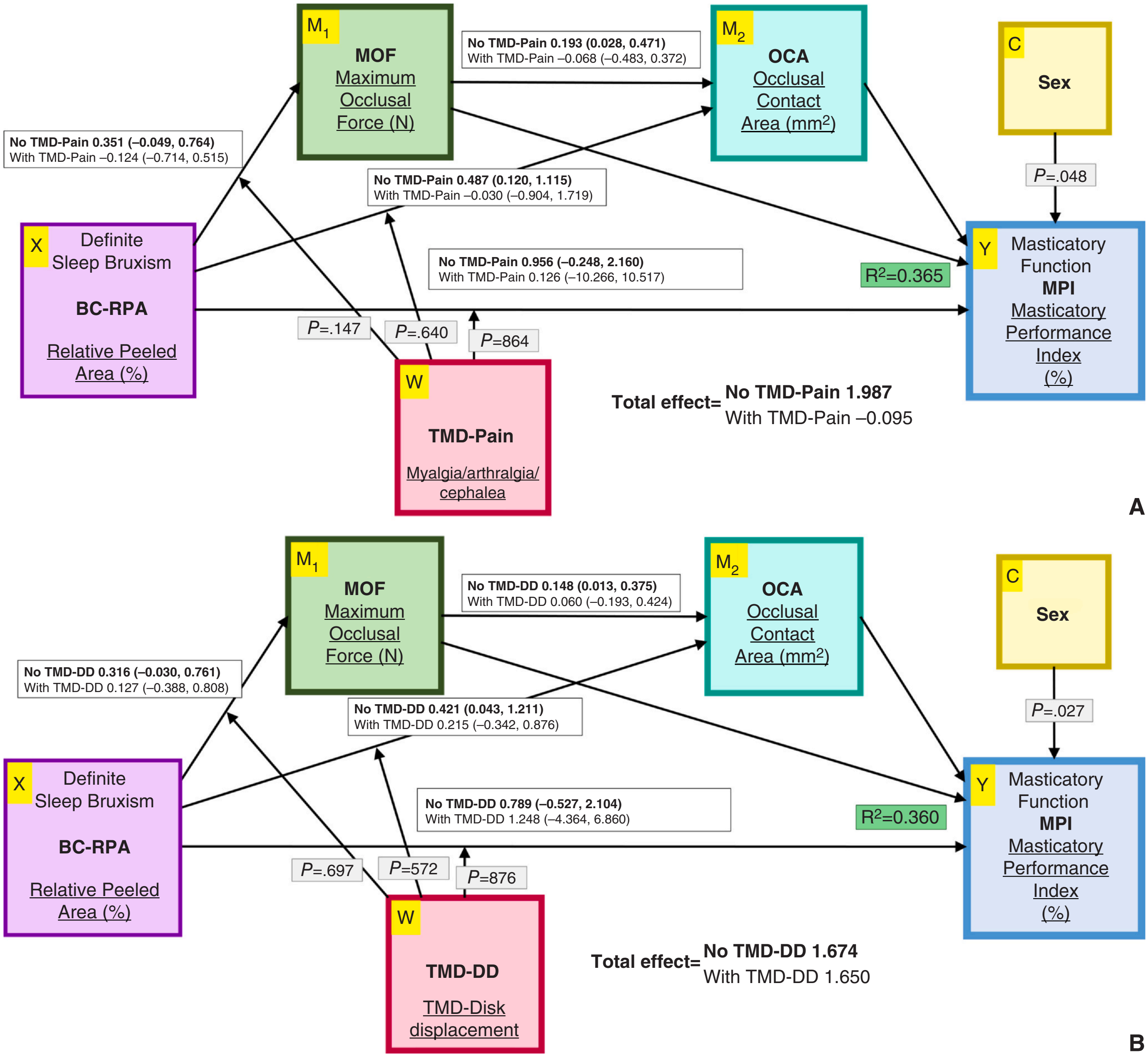

Figure 2. Moderation of variables in mediation of occlusal force and occlusal contact area between sleep bruxism and masticatory performance, adjusted by sex. A, TMD pain. B, TMD disk displacement. C, Bruxism-related jaw symptoms moderation in mediation of occlusal force and occlusal contact area for relation between sleep bruxism and masticatory performance, adjusted by sex as covariate. Unstandardized regression coefficients for indirect and direct effects reported for each group. Model 85: n=82; bootstrap 95% CIs in parentheses. CI, Confidence interval; TMD, temporomandibular disorder.

clinical consequences of sleep bruxism, particularly its grinding component. However, the BruxChecker is not suitable for assessing clenching activity during sleep, as self-reported sleep clenching did not correlate with the relative peeled area or perforation of the BruxChecker.[5] The clenching component of sleep bruxism could be more objectively evaluated by using electromyographic monitoring during sleep in combination with oral appliances equipped with sensors.[42]

Limitations of the present study included that, although the sample size was sufficient to detect the mediation effect of MOF and OCA in the relationship between sleep bruxism and masticatory performance, the low percentage of individuals with TMD pain, TMD disk displacement, or frequent bruxism-related jaw symptoms led to an insignificant moderation effect. Increasing the number of participants in this group or including patients who seek treatment for TMD could

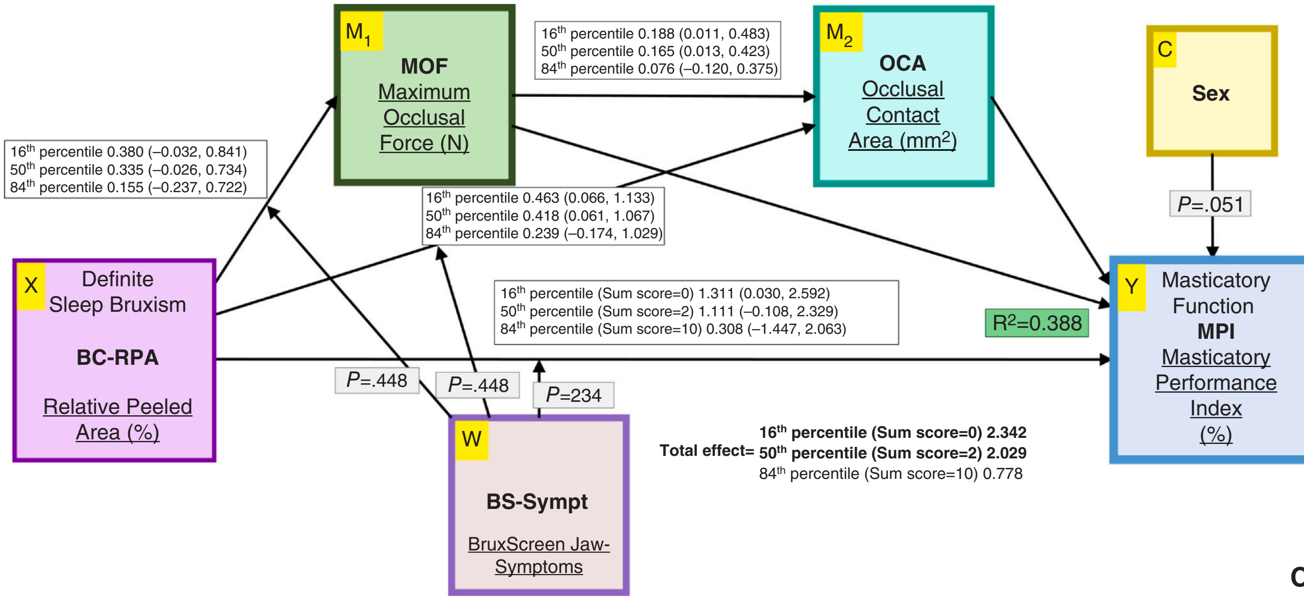

Figure 2. (*continued*)

offer novel insights into the field of TMD and orofacial pain. Importantly, the present sample was not sex balanced, with a much higher number of women participants. Given that men have better masticatory performance, sex was included as a covariate to enhance model precision and assess whether sleep bruxism at the dental level affects masticatory performance, regardless of sex.

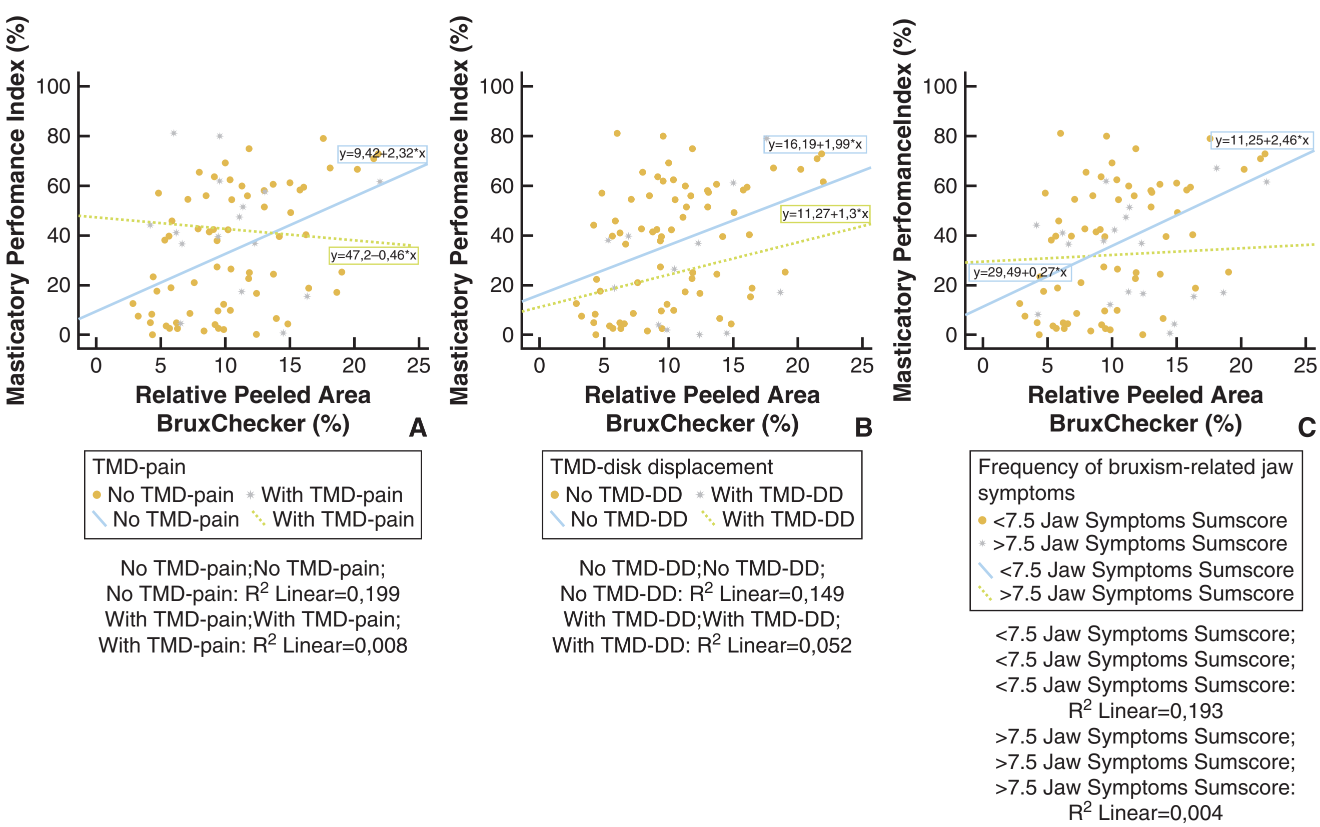

Figure 3. Correlation between BruxChecker relative peeled area and masticatory performance index. A, Moderation by presence or absence of TMD pain. B, Moderation by presence or absence of TMD disk displacement. C, Moderation by nonfrequent (sum score <7.5) or frequent (sum score >7.5) bruxism-related jaw symptoms. TMD, temporomandibular disorder.

CONCLUSIONS

Based on the findings of this clinical study, the following conclusions were drawn:

1. Sleep bruxism may improve masticatory performance in young adults with healthy dentitions through a process that is mainly mediated by an increase in occlusal force and an enlargement of the OCA.
2. However, sleep bruxism does not appear to improve masticatory performance in individuals with TMD pain or frequent jaw symptoms related to bruxism.
3. The enhancement of masticatory performance can be considered a positive health effect of sleep bruxism.

PATIENT CONSENT

Written informed consent was obtained from all individual participants included in the study.

ETHICS APPROVAL STATEMENT

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of the Barcelona University Dental Hospital (Ref. 25/2023; November 3, 2023).

APPENDIX A. SUPPORTING INFORMATION

Supplemental data associated with this article can be found in the online version at doi:10.1016/j.prosdent.2025.03.029.

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CRediT authorship contribution statement
Mireia Ustrell-Barral: Conceptualization, Methodology, Validation, Investigation, Writing- original draft, Visualization. **Carla Zamora-Olave:** Conceptualization, Methodology, Resources, Writing- reviewing and editing, Supervision. **Laura Khoury-Ribas**: Conceptualization, Methodology, Writing- reviewing and editing. **Bernat Rovira-Lastra**: Conceptualization, Methodology, Resources, Writing- reviewing and editing, Supervision. **Jordi Martinez-Gomis**: Conceptualization, Methodology, Validation, Investigation, Formal analysis, Writing- original draft, visualization, Supervision.

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