

Bruxism as a new Risk Factor of Musculo-Skeletal Disorders?

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Short title: Association between bruxism and musculo-skeletal disorders

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Abstract

Objectives: Musculoskeletal disorders (MSDs), particularly neck and low back pain, constitute a major public health issue worldwide with a heavy morbidity and economic impact. However, the relationships between the stomatognathic system and MSDs are subjected to debate, data sorely lacking. The study objective was to investigate the association between bruxism (BR) and MSDs. Secondary objective includes the study of the association between tooth wear (TW) and MSDs.

Methods: This is a cross-sectional study on 425 participants frequenting a university dental clinic. The presence of MSDs was evaluated with the standardized Nordic questionnaire. The sleep and awake BR assessments were based on clinical examination and self-report. TW was measured with the BEWE index. Socio-demographic factors, medical history, life habits and stress were analyzed as potential confounding variables.

Results: 91% of patients reported at least one MSD during the preceding 12 months and 78.8% were diagnosed as bruxers. In multivariate analyses, BR was associated with a 5-fold increased risk of prevalent MSD (OR=5.88 (2.7-12.5), $p<0.0001$). Regarding TW, for a one-point increase in anterior BEWE score, the risk to present an MSD was increased by 53% (OR=1.53 (1.12-2.08), $p=0.0076$). Moreover, BR was independently associated with neck, shoulder, upper back, low back, hip & thigh and knee MSDs. Anterior TW was independently associated with neck, low back and hip & thigh MSDs, and global TW with knee MSDs.

Conclusions: BR and TW were shown to be associated with MSDs. The cause-and-effect relationships between those factors needs to be analyzed to optimize prevention and therapeutic care.

Clinical significance: Results suggest that the body is a whole, a balanced muscular system, where every part constitutes a link of the chain. MSDs management and prevention may require

a multidisciplinary team approach and future perspectives include defining the dentist's role in this context, particularly with respect to BR diagnostic and treatment.

1. Introduction

Musculoskeletal disorders (MSD) are soft-tissue injuries caused by sudden or sustained exposure to repetitive motion, force, vibration, and awkward positions. These disorders can affect the muscles, nerves, tendons, joints and cartilage [1]. According to the WHO [2], MSDs affect around 1,71 billion persons worldwide and constitute a major public health issue. Studies on the prevalence of MSDs in healthy adult populations are lacking but a systematic review and meta-analysis on the prevalence of work-related MSDs in secondary industries showed that MSDs of the back, shoulder and neck are very common, with mean 12-month prevalence values ranging from 47 to 60% [3]. In the study of Wijnhoven, 39% of men and 45% of women reported chronic musculoskeletal pain in any body region [4]. MSDs are associated with a huge morbidity and have a significant economic impact increasing with population, while young people are also affected [2]. They engender not only direct costs, related to medical expenditure, but also indirect costs, including lost work output, as well as intangible costs, related to the psychosocial burden [5]. Particularly, neck and low back pain were reported to be one of the most important causes of the world global burden of disease in 2016, low back pain being in the top ten for all countries, while neck pain in the top for half of the countries [6]. In 2019, low back pain was in the top ten of the diseases, which engendered the highest amount of years lived with disability (YLDs), while other MSDs ranked the 19th cause out of 369 [7]. If 40% of low back pain are reported to be attributed to occupational risks or increased BMI [6], data about neck pain risk factors are lacking.

On the other hand, following the international consensus, bruxism (BR) is defined as “a repetitive masticatory muscle activity that is characterized by clenching or grinding of the teeth and/or by bracing or thrusting of the mandible, and that is specified as either sleep BR or awake BR, depending on its circadian phenotype” [8]. In healthy individuals, BR should not be considered as a disorder, but rather as a behavior that can be a risk (and/or protective) factor for

certain clinical consequences [8]. Indeed, in some individuals this behavior may have positive consequences for the bruxer and reduce the likelihood of a negative health outcome (e.g., being the last episode of respiratory arousals, so as to prevent the collapse or restore the patency of the upper airway whilst asleep) [8]. On the other hand, BR is a sign of certain clinical conditions and symptoms as it has been reported to be associated (without a causal relationship) with various factors and pathologies, such as obstructive sleep apnea, gastro-esophageal reflux, headache or temporo-mandibular disorders (TMDs), such as localized masticatory muscle pain [9-15]. TW (loss of dental hard tissues from the surface by means other than dental caries, trauma or development disorders) particularly mechanical TW, may be an indicator of sleep and awake BR [8]. TW is promoted by changing lifestyles, particularly chemical erosion, which is favored by acidic food/drinks (like sodas) and gastroesophageal reflux (GER) [16, 17], while mechanical wear is often related to the presence of BR, which engenders attrition (from surface TW due to friction) and abfraction (loss of tooth tissue near the junction with gingiva due to mechanical stress) [8] [18]. TW is reported to have a high and increasing prevalence, particularly in young patients [19-22] [23]. An earlier study reported that TW affects 68.8% of the population between 16 and 97 years old in the United States, with 9.6% showing extreme TW [24]. In the Netherlands, moderate and severe TW affected 80% and 6% of the adult population, respectively [22]. In severe TW cases, patients can suffer from dental pain and psycho-social handicap due to impaired esthetics, masticatory dysfunction, TMDs, masticatory muscles, and orofacial pain due to BR [25, 26], with a significant impact on the oral health-related quality of life [27], requiring complex rehabilitation [28-32].

In 2012, the findings of Hellmann et al. [33] supported the assumption of a relationship between jaw clenching and the activity of the neck muscles, while in 1997 Bader et al. [34] noticed, in a sample of 24 bruxers, that 69% of them complained about neck, back, shoulder, or chest pain. However, there is a lack of data regarding the association between BR or TW (as a

symptom of BR) and MSDs (except localized masticatory muscle pain). Consequently, the objective of this cross-sectional study was to investigate the association between BR and MSDs. A secondary objective was to study the association between tooth wear (TW) related to BR and MSDs.

2. Materials and methods

2.1. Study design

The protocol of this cross-sectional study was approved by the Ethics Committee of the University Hospital Center (CHU) of Liege and was conducted in accordance with the guidelines set out in the Declaration of Helsinki as revised in 2000, and all applicable local regulations and standards (file: B707201629113, approved 25/03/2019) and was registered on the ClinicalTrials.gov database (Identifier NCT02150226). Participants in this study underwent a clinical examination and completed self-administered questionnaires.

2.2. Participants and settings

2.2.1. Settings

The study was carried out on patients from the Institute of Dentistry, University Hospital, Liège, Belgium. Between April 2019 and December 2019, any patient with the eligible criteria visiting the dentists appointed as clinical evaluators was asked to participate in the study. Moreover, dental students, dental assistants and dentists working at the Institute of Dentistry and fulfilling the eligible criteria were also asked to participate in the study.

2.2.2. Inclusion/exclusion criteria

Patients were eligible to participate in the study if they were between 18 and 80 years old, had a minimum of 8 teeth with dental tissue in occlusion (minimum 1 tooth per sextant), mastered the language of the survey questionnaires (French), and had the mental capacities necessary to participate in the study. Patients were excluded if they were visiting for a painful dental

emergency, were under orthodontic treatment (or had it completed less than 2 months before) or were wearing a one-piece bimaxillary orthodontic retainer (post class 2 treatment). Inclusion was validated after consent signature.

2.2.3. Evaluators

The clinical evaluators were 4 experienced dentists, who are trained clinical researchers of the department of fixed prosthodontics, Institute of Dentistry, University Hospital, Liège, Belgium, and 2 postgraduate students. Evaluators were trained by means of group sessions. After the clinical evaluation, a self-administered questionnaire was given to the participants, while the researchers remained at their disposal for any information during the filling out of the forms.

2.2.4. Participant incentives

The participants received no financial compensation.

2.3. Data collection

2.3.1. Musculoskeletal disorders (MSDs)

The French version of the Nordic questionnaire [35] was used to evaluate the presence of MSDs. The standardized Nordic questionnaire is a validated tool to evaluate the musculoskeletal health in the context of occupational health [36]. It includes data collection about MSDs confounding factors (see below) and MSDs self-report in 9 regions of the body: neck, shoulder, upper back, low back, hip and thigh, knee, ankle and foot, elbow and wrist and hand. Particularly, it focuses on the reporting of MSDs symptoms presence during the past 7 days, 12 months, and whole life, as well as on the consequences on the patient's professional and leisure activities. In the present study, only data about the presence of MSDs during the past 12 months were used, i.e. answers to the following question for each body region: "In the last 12 months, have you had any problems (aches pain, discomfort) in the following body region: yes or no" (the questionnaire includes filling information and a figure, which shows the

different body regions). Moreover, in addition to questions of the Nordic questionnaire, reported pain level in each body region was self-reported on a 10-point scale.

2.3.2. Bruxism (BR)

The presence of sleep and/or awake BR was based on clinical inspection and self-report with a questionnaire. Particularly, sleep BR was assessed according to the criteria of the American Academy of Sleep Medicine, and the patient was categorized as sleep bruxer if he/she fulfilled at least two criteria: A) reporting of tooth grinding during the night (including the presence of grinding noise reported by bed partner); B) the presence of at least one clinical sign among the following: presence of attrition wear facets on the teeth (mechanical TW); transitory pain or fatigue on waking felt in the jaw muscles; temporal headaches on waking; and jaw locking on waking related to teeth grinding during sleep [37] [23]. For awake BR, AASM criteria were adapted, and the criteria A was defined as clenching and/or bracing/thrusting the teeth at work or when concentrating on a specific task, clenching and/or bracing/thrusting the teeth, playing with muscles bracing teeth, and tooth grinding during the day. Before answering the questionnaire, the clinical evaluator made the patient aware of what is meant by clenching and bracing/thrusting, most easily defined as the teeth touching not for swallowing purposes, and as increased levels of masticatory muscle activity without tooth contacts, respectively [38].

In addition, a masticatory muscles examination was carried out to complete information about BR symptoms in the studied population:

- *Masseteric hypertrophy*: The presence of jaw asymmetry at rest, important muscle volume increase (around 3 times) when clenching, or concavities on the lower edge of the mandibular bone at the place of muscle insertion (called gonial eversion, visible on the panoramic radiograph if available), was recorded. The presence of nodules (muscle contraction) on muscle palpation was also recorded.

- *Pain on palpation:* Pain on palpation, by applying a 1kg pressure approximatively, with three fingers (index, major and annular) and going through the whole muscle, was recorded for both pairs of the masseters, temporal and sternocleidomastoid muscles. During that examination, teeth were in occlusal contact but without clenching. For pressure application, the evaluators were trained using a scale. The presence of muscular tension in the sternocleidomastoid muscles was also evaluated.

2.3.3. Tooth wear (TW)

TW evaluation

The Basic Erosive Wear Examination index (BEWE) [39] was used to quantify TW. Two cumulative scores were calculated: the global score (as presented by Bartlett et al.) [39] and the anterior score, the latter considering only sextants 2 and 5.

TW type determination

TW was assessed as being mechanical and/or chemical. The presence of mechanical TW was recorded in the presence of attrition facets eventually associated with the presence of other BR clinical signs, such as tooth cracks/fractures, linea alba, exostoses, crenated tongue, masseteric hypertrophy or pain on masticatory muscle palpation [37] [38]. The presence of chemical TW was recorded in the presence of dental erosion surfaces (concave, cuneiform or flat lesions) eventually associated with the presence of chemical TW risk factors related to nutrition habits (e.g. consumption of acidic food/drinks), general diseases (e.g. gastro-esophageal reflux presence), medications and environmental factors, which were recorded in a questionnaire.

2.3.4. Confounding factors

Socio-demographic data

The self-administered questionnaire included the collection of data about the patients' age, sex, socio-professional status, level of education and perception of income level.

Nordic questionnaire related data

The general information part of the Nordic questionnaire includes data collection about the body mass index (BMI), work schedules and physical workload (light, average, heavy or very heavy) of the patients.

Medical data

Data were collected about participants' medical background, particularly about factors reported to be associated with BR, TW or MSDs. Those data included the presence of cervical trauma history, motor or neuronal disorders, sleep apnea diagnostic and gastro-esophageal reflux.

Life habits

Life habits in terms of smoking and physical activity (at least 2h30 of moderate activity or 75 minutes of intense activity per week) were recorded. The regular use of an occlusal nightguard was also recorded.

Stress

The level of stress was measured using the Perceived Stress Scale 14 (PSS14) developed by Cohen et al., 1983 [40]. The questionnaire consists of 14 items. Each patient was asked to rate the frequency of his/her stress feelings on a 5-point Likert scale from a score of 0 "never" to a score of 4 "very often". For items 4-7, 9, 10 and 13, the scale was reversed (score 0; very often and score 4; never). The total score is calculated by summing the scores of the 14 items.

2.4. Data management

Data were collected, stored and processed in the Department of Fixed Prosthodontics, Institute of Dentistry, University Hospital, Liege, Belgium. Patients were identified by their inclusion number in order to preserve their privacy. Data encoding was double-checked, and database quality was verified by a data manager. Only the data manager and the statisticians have unrestricted access to the database.

2.5. Statistical analyses

2.5.1. Sample size

In order to determine the number of subjects to be included in the present study, a power calculation based on the width of the confidence interval for a proportion was performed. Specifically, as there was no data available on the prevalence of musculoskeletal disorders and associated BR/TW, the power calculation was performed using a proportion of 50%. This proportion, thus, allows the sample size to be maximized. The precision was set at 5%, so the sample size was 385 subjects.

2.5.2. Statistical analysis

The results are expressed as median and interquartile range (P25-P75) due to skewed distribution. Normality was investigated by comparing means and medians, investigating graphically histograms and Q-Q plots and performing the Shapiro-Wilk test. Categorical variables are summarized using numbers and frequencies (%). The association between BR and each MSD/presence of at least one MSD was investigated using a Chi-square test or Fischer's exact test if the conditions of application were not met while the association between the global (resp. anterior) TW and each of the musculoskeletal disorders (MSDs)/presence of at least one MSD was analyzed using a non-parametric Kruskal-Wallis test. Same analyses were performed between each of the MSDs/presence of at least one MSD and the following confounding factors: age, BMI, stress, sex, perception of income receipt, tobacco, physical activity, gastro-esophageal reflux, cervical trauma history, motor neurone disorders, occlusal nightguard wearing, sleep apnea, work schedules and workload. A multivariate binary logistic regression was then performed to test the association between global TW (resp. anterior and bruxism) and each MSD/presence of at least one MSD, controlling for significant confounding factors. The results will be presented as an odds ratio (OR) with the corresponding 95% confidence interval

(95% CI). A Firth correction was applied when necessary. The association between the clinical signs of BR-and being a bruxer or not was tested using the Chi-square test or Fisher's exact test. The results were considered significant at the 5% uncertainty level ($p < 0.05$). Calculations were always performed on the maximum number of observations available. The statistical software used was SAS 9.4 (for Windows).

3. Results

A total of 425 patients (41.1% men and 58.9% women) were included in the study between April and December 2019. The median age (P25-P75) was 38 (26-54) years.

3.1. Prevalence of MSDs and BR- BEWE TW scores

Results about the prevalence of awake and sleep BR and BEWE cumulative scores for global and anterior TW are presented in Table 1. The median (P25-P75) global BEWE score in the sample was 7 (5-10) and the median anterior score was 4 (2-4). The TW etiology was mainly mechanical: only 1.9% of the sample had only chemical TW, while 67.0% had only mechanical TW and 28.5% had both (only 2.6% did not show TW). Results about the prevalence of MSD and related pain levels (distinguishing the 9 regions of the body of the Nordic questionnaire) are presented in Table 2. The most often reported MSDs were neck and lower back pain (65.0 and 60.3% of the studied sample, median pain level of 5 on 10), while 91 % of the participants reported at least one MSD.

3.2. BR diagnostic criteria

Results about the prevalence of the different BR diagnostic criteria in the studied population are presented in Table 3. Patients fulfilling at least one criteria A and one criteria B were categorized as bruxers (awake and/ or sleep). The association between the bruxers population and other BR clinical signs related to masticatory muscles (see 2.3.1.1) is also presented. All

those clinical signs were shown to be significantly more present in the bruxers population, except masseter muscle hypertrophy and gonial eversion (Table 3).

3.3. Association between BR, TW and the presence of at least one MSD

Results related to the association between the presence of at least one MSD and the studied parameters (socio-demographic factors, medical history, life habits and stress) are presented in Table 4.

After multivariate analysis, BR and anterior TW were shown to be significantly associated with the presence of at least one MSD ($p < 0.0001$ and $p = 0.0076$, respectively) (Table 5). The presence of sleep BR only was not associated with the presence of at least one MSD, unlike the presence of awake, or awake and sleep BR (Table 5). Age, stress and cervical trauma history were also shown to be independently and significantly associated with the presence of at least one MSD.

3.4. Association between BR, TW and MSDs per body region

Figure 1 shows the results of the multivariate analyses performed for each of the 9 regions of the body evaluated, indicating the different regions affected by MSDs, which were significantly associated with the presence of BR, anterior TW and/or global TW, with their corresponding OR. All OR were adjusted for significant confounding factors among age, BMI, stress, sex, perception of income receipt, tobacco, physical activity, gastro-esophageal reflux, cervical trauma history, motor neurone disorders, occlusal nightguard wearing, sleep apnea, work schedules and workload. Figure 1 also indicates the confounding factors which were shown to be significantly associated with MSDs in those regions-

4. Discussion

In the present study, BR was associated with a 5-fold increased risk of prevalent MSD (OR=5.88 (2.7-12.5), $p < 0.0001$) and for one-point increase in anterior TW score, the risk to present an MSD

was increased by 53% (OR=1.53 (1.12-2.08), $p=0.0076$). Additionally, the influence of age, stress and cervical trauma history on MSDs prevalence were also highlighted. This study on the presence of a MSD per body region also demonstrates the influence of global TW and reveals the influence of other parameters, such as BMI and workload, which constitute well-known risk factors of MSDs. More specifically, BR was independently associated with neck, shoulder, upper back, low back, hip and thigh, and knee MSDs, while anterior TW was associated with neck, low back and hip and thigh, and global TW was associated with knee MSDs. Odds ratios were found to be particularly high for BR in some regions, such as neck (OR=3.05 (1.88-4.92)).

In our sample, BR prevalence was very high (75.5%), awake BR being more frequent than sleep BR (71.3% versus 41.9% of the sample, respectively), which is much higher than the general picture obtained from the literature. However, the objective of this study was not to determine BR prevalence among the local population, and the studied sample was not designed to be representative of this population. It was constituted of patients and personnel frequenting the University Hospital, particularly regular patients of the evaluators, who may treat a significant number of patients for bruxism-related TW. However, it can be suspected that BR prevalence is higher than usually reported. The prevalence of MSDs in the studied sample was also found to be very high (91% of patients reported at least one MSD during the preceding 12 months). The sensitivity of the Nordic questionnaire being reputed to be very good [41], the high MSD prevalence can be explained by the fact that the questionnaire explored symptoms in the past year, which is a long period of time, and included all pain levels, even low-level pain. It should also be noted that in the recent systematic review and meta-analysis on the prevalence of work-related MSDs in secondary industries, back, shoulder and neck MSDs can reach 12-month prevalence values in the range of 70-80% [3]. Neck and low back pain were the more frequently reported MSDs (65% and 60.3% of the sample, respectively), which confirms results of the world global burden of disease report [6]. It must be noticed that the

median pain levels were found to be moderate in all regions (median pain levels between 4 and 5 out of 10).

Some MSDs were previously reported to be related to body posture [42, 43] and a few studies have shown a correlation between the stomatognathic system and the body posture, although this topic is highly controversial [43-46]. Some authors highlighted a correlation between jaw position and body posture [47-49], or masticatory dysfunction and neck pain [50], while other authors have reported that there is no link between dental occlusion and the full body [51]. However, a good balance between the masticatory muscles and the head and neck muscles seems to be an important factor for postural stability [52, 53], and some studies have underlined the need to achieve an interdisciplinary approach in complex treatments combining dentists, physiotherapists and posturologists [54, 55]. Posturology studies the relationship between posture and different pathologies, above all the chronic pain, but there is a lack of scientific evidence in that field [56, 57], while postural sway is also analyzed in the field of sport [58]. In particular, the concept of muscular chains was introduced in the seventies by Françoise Mézières [59]. The idea is to stretch at the same time all the muscles contained in a group called muscular chain to correct posture, working with body alignment [42]. Within a muscular chain, muscles are positioned in a longitudinal manner following the same direction and are connected through fascia [49], which are considered by some authors as an important element in musculoskeletal pain, since they can transmit mechanical tension generated by muscular activity through the body. This explanation could support the influence of BR on MSD, and one hypothesis is that reducing BR could, in turn, reduce MSDs. Yet, the effect of physiotherapy and behavioral change strategy in BR treatment has been poorly studied [60], even if there is some evidence to support the use of occlusal splints plus massage or botulinum toxin to reduce related chronic pain [61]. In the present study, the presence of sleep BR alone was not associated with the presence of MSD (Table 5). One hypothesis is that most bruxistic

episodes in sleep BR are phasic (grinding) with a few tonic or sustained contractions in contrast to clenching/bracing whereas awake BR is generally characterized by more sustained contractions, and has been reported to cause more orofacial muscular pain than SB [62-64]. However, these findings should be interpreted with caution due to the small sample size (n=18) of patients with sleep BR only. In any case, results of the present study suggest that the body is a whole and that some phenomenon can have long-distance effects.

The main challenge and limitation of the present study is related to BR diagnostic. Indeed, BR diagnostic approaches can be non-instrumental, involving self-report (possible awake/sleep BR, following the bruxism assessment grading system proposed by the international consensus), or clinical inspection (probable awake/sleep BR), or instrumental using polysomnography (PSG) or electromyography (EMG), which are reported to increase diagnostic reliability (definite awake/sleep BR) [8]. However, the use of an instrumental approach in a large sample size, such as the one calculated for this cross-sectional study, was not feasible. The BR diagnostic is complex, which explains that prevalence data are variable and restricted, particularly for awake BR (reported prevalence is 22-30% for awake BR and 1-15% for sleep BR, a prevalence up to 49% being observed in younger patients) and instrumental approaches are poorly used [10]. If attrition (mechanical TW) is an indicator of awake and sleep BR, it does not allow to exclude a past sleep BR without current activity [8], highlighting the importance of self-report and clinical inspection of other symptoms of BR. In the present study, a self-report based on an important questionnaire filled by the patient after its education by the evaluator, was combined with an in-depth clinical inspection of reported BR clinical signs, including examination of masticatory muscles. This inspection was conducted by trained evaluators. Special attention was paid to slight attrition facets, since BR can induce only slight damage to dental hard tissues, particularly in young people or in case of predominance of clenching habits (which do not engender a friction effect) (Figure 2). This fact explains the

introduction of an anterior TW score in the present study, and the TW degree of severity was shown to be higher in the anterior region than globally (median BEWE anterior score of 4 on 6 versus 7 on 18 for the global score) (Table 1). The presence of attrition facets was the most often observed B criteria for defining BR (Table 2). The analysis of the population defined as bruxers (Table 3) shows that this population had also significantly more BR masticatory muscle-related symptoms than the rest of the sample, which supports the BR assessment method used. It can also be noticed that an important part of bruxers reported clenching during the day, which is a symptom that cannot be disputed.

The future perspective of our research is that we may need to involve multidisciplinary research teams in health care in order to analyze the complex relationships observed and to define the role of the dentists in MSD management and prevention, especially with respect to BR diagnostic and treatment.

5. Conclusion

Within the limitations of the present study, BR and TW, particularly mechanical TW, which constitutes a BR symptom, were shown to be associated with MSDs. Further research is needed to confirm those results and more particularly a longitudinal study will be needed to assess if BR or TW are real risk factor for MSDs incidence. Results suggest that the body is a whole, a balanced muscular system, where every part plays its role as a link of the chain.

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Figures captions

Table 1 Prevalence of BR (distinguishing awake and sleep BR) and BEWE cumulative scores expressed as median and interquartile range (P25-P75) for global and anterior TW.

Bruxism	n tot	Global n (%)	Awake Bruxism n (%)	Sleep Bruxism n (%)	Sleep ad Awake Bruxism n (%)
	425	321 (75.5)	303 (71.3)	178 (41.9)	160 (37.7)
Tooth Wear BEWE score	n tot	Global score (P25-P75)		Anterior score (P25-P75)	
	421	7 (5-10)		4 (2-4)	

Table 2 Prevalence of Musculo-skeletal disorders (MSD) and related pain levels (distinguishing the 9 regions of the body analyzed in the Nordic questionnaire) expressed as median and interquartile range (P25-P75).

	MSD - Prevalence n (%) n tot = 423	Median pain level (P25-P75) n tot = 423
At least 1 TMS	386 (91.0)	NA
Neck	275 (65.0)	5 (3-7)
Lower back	255 (60.3)	5 (3-6.5)
Upper back	187 (44.2)	5 (3-6)
Shoulder	183 (43.3)	5 (3-6)
Knee	147 (34.8)	4 (3-6)
Wrist/Hand	120 (28.4)	5 (3-6)
Ankle/foot	101 (23.9)	5 (3-6)
Hip/Thigh	98 (23.2)	5 (3-7)
Elbow	48 (11.3)	4 (2-6)

Table 3 Prevalence of the different bruxism (BR) diagnostic criteria examined in the studied population (patients fulfilling at least one criteria A and one criteria B were categorized as bruxers) and prevalence of other BR clinical signs related to masticatory muscles in the bruxers population specifically, with results of statistical analysis. * Indicates that a significant association was detected between the BR diagnostic and the presence of muscular pain ($p < 0.05$).

BR Diagnostic Criteria A	n tot	Yes; n(%)		
Tooth grinding-awareness (by night)	425	85 (20.0)		
Tooth grinding-sound (by night)	424	78 (18.7)		
Feeling of tooth clenching (upon awakening)	422	145 (34.3)		
Tooth clenching (during activity)	424	260 (61.4)		
Jaw muscle clenching (by day)	424	189 (44.6)		
Feeling of tooth clenching (by day)	423	210 (49.3)		
BR Diagnostic Criteria B	n tot	Yes; n(%)		
Abnormal tooth wear (presence of attrition facets; BEWE \geq 1)	425	415 (97.6)		
Jaw muscle pain or fatigue (upon awakening)	425	125 (29.4)		
Temporal pain (upon awakening)	423	84 (19.9)		
Jaw locking (upon awakening)	425	27 (6.4)		
Jaw muscle pain or fatigue (by day)	425	130 (30.6)		
Temporal pain (by day)	425	92 (21.6)		
Other BR clinical signs	n tot	Yes; n(%)	Prevalence in the BR population (%)	Association with BR diagnostic (p value)
Jaw asymmetry	417	92 (21.7)	25.6	0.00019*
Masseter muscle hypertrophy	425	94 (22.7)	24.4	0.14
Gonial eversion	416	154 (37.0)	34.7	0.087
Nodules in the masseter	403	171 (42.4)	47.2	0.0008*
Pain on masseter muscle palpation	422	164 (38.9)	44.8	<.0001*
Pain on temporal muscle palpation	422	104 (24.6)	29.8	<.0001*
Pain on sterno-cleido-mastoid muscle palpation	422	190 (45.0)	50.2	0.0002*
Sterno-cleido-mastoid tension	421	253 (60.1)	63.8	0.0059*

Table 4 Results related to the association between the presence of at least one MSD and the confounding factors (socio-demographic factors, medical history, life habits and stress). (1): Non-parametric Mann-Whitney test. (2): Chi-squared test. (3): Fisher exact test. * Indicates that a significant association was detected ($p < 0.05$).

Variables	Categories	n	At least one MSD		p-value
			Yes Value (%)	No Value (%)	
Age (years)		380	39.0	32.0	0.019 ⁽¹⁾
Median (Q1 – Q3)			(27.0 – 54.0)	(23.0 – 44.5)	
Sex		384		37	0.44 ⁽²⁾
	Men		160 (41.7)	13 (35.1)	
	Women		224 (58.3)	24 (64.9)	
BMI (kg/m ²)		376	23.7	21.8	0.088 ⁽¹⁾
Median (Q1 – Q3)			(21.2 – 26.7)	(19.9 – 25.0)	
Income receipt		380		36	0.29 ⁽²⁾
	Difficult		81 (21.3)	5 (13.9)	
	Easy		299 (78.7)	31 (86.1)	

Variables	Categories	At least one MSD				p-value
		n	Yes	n	No	
			Value (%)		Value (%)	
Smoking		386		37		0.18 ⁽²⁾
	Non-smoker		263 (68.1)		30 (81.1)	
	Smoker		61 (15.8)		2 (5.4)	
	Ex-smoker		62 (16.1)		5 (13.5)	
Physical activity		379		37		0.99 ⁽²⁾
	No		102 (26.9)		10 (27.0)	
	Yes		277 (73.1)		27 (73.0)	
Gastro-esophageal reflux		372		36		0.14 ⁽²⁾
	No		280 (75.3)		31 (86.1)	
	Yes		92 (24.7)		5 (13.9)	
Cervical trauma history		381		36		0.037* ⁽³⁾
	Non		342 (89.8)		36 (100.0)	
	Oui		39 (10.2)		0 (0.0)	
Physical workload		347		32		0.52 ⁽²⁾
	Light		216 (62.2)		23 (71.9)	
	Average		78 (22.5)		6 (18.8)	
	Heavy/very heavy		53 (15.3)		3 (9.4)	
Motor/neuronal disorders		380		36		1.00 ⁽³⁾
	Non		371 (97.6)		36 (100.0)	
	Oui		9 (2.4)		0 (0.0)	
Stress score		382	22.0	37	20.0	0.040* ⁽¹⁾
Median (Q1 – Q3)			(18.0 – 28.0)		(15.0 – 24.0)	
Occlusal nightguard wearing		382		37		0.81 ⁽³⁾
	No		319 (83.5)		33 (89.2)	
	Yes regularly		45 (11.8)		3 (8.1)	
	Yes rarely		18 (4.7)		1 (2.7)	
Work schedules		283		25		0.25 ⁽²⁾
	Regular		195 (68.9)		20 (80.0)	
	Flexitime		88 (31.1)		5 (20.0)	
Sleep apnea		386		37		0.22 ⁽³⁾
	No		356 (92.2)		35 (94.6)	
	Yes		22 (5.7)		1 (2.7)	
	Before		7 (1.8)		0 (0.0)	

Table 5 Results related to the association between the presence of at least one MSD and BR, global TW and anterior TW respectively, with corresponding Odds ratios (OR) and related 95% confidence intervals). P value are presented after adjustment by age, stress and cervical trauma.

* Indicates that a significant association was detected ($p < 0.05$). (1): Univariate analysis. (2): Adjusted by age, stress and cervical trauma.

Variables	At least one MSD n=386 (91.0%)	No MSD n=37 (9.0%)	p-value ⁽¹⁾	OR (95% CI) ⁽²⁾	Adjusted p-value ⁽²⁾
	N = 386	N = 37			

Bruxism n (%)	304 (78.8%)	16 (43.2%)	< 0.0001*	5.88 (2.7 – 12.5)	< 0.0001*
Bruxism n (%)			<0.0001*		0.0001*
Awake	133 (41.5%)	10 (27.0%)		4.27 (1.82 – 10.0)	0.0008*
Sleep	18 (5.6%)	0 (0.0%)		8.96 (0.47 – 170.9)	0.14
Awake/sleep	153 (47.8%)	6 (16.2%)		7.36 (2.68 – 20.2)	0.0001*
	N = 384	N = 36			
Global TW Median (Q1 – Q3)	8.00 (5.00 – 10.00)	6.00 (3.00 – 7.50)	0.003*	1.09 (0.99 – 1.21)	0.087
	N = 384	N = 36			
Anterior TW Median (Q1 – Q3)	4.00 (2.00 – 4.00)	2.00 (2.00 – 4.00)	< 0.0001*	1.53 (1.12 – 2.08)	0.0076*

Figure 1 Results of the multivariate analyses performed for each of the 9 regions of the body evaluated, indicating the different regions affected by MSDs, which were significantly associated with the presence of bruxism (BR), anterior tooth wear (TW) and global TW (in red, orange and yellow, respectively, with corresponding Odds ratios (OR) and related 95% confidence intervals). All OR were adjusted for significant confounding factors among age, BMI, stress, sex, perception of income receipt, tobacco, physical activity, gastro-esophageal reflux, cervical trauma history, motor neurone disorders, occlusal nightguard wearing, sleep apnea, work schedules and workload. NS= no significant association detected. The figure also indicates the confounding factors which were shown to be significantly associated with MSDs in those regions:-

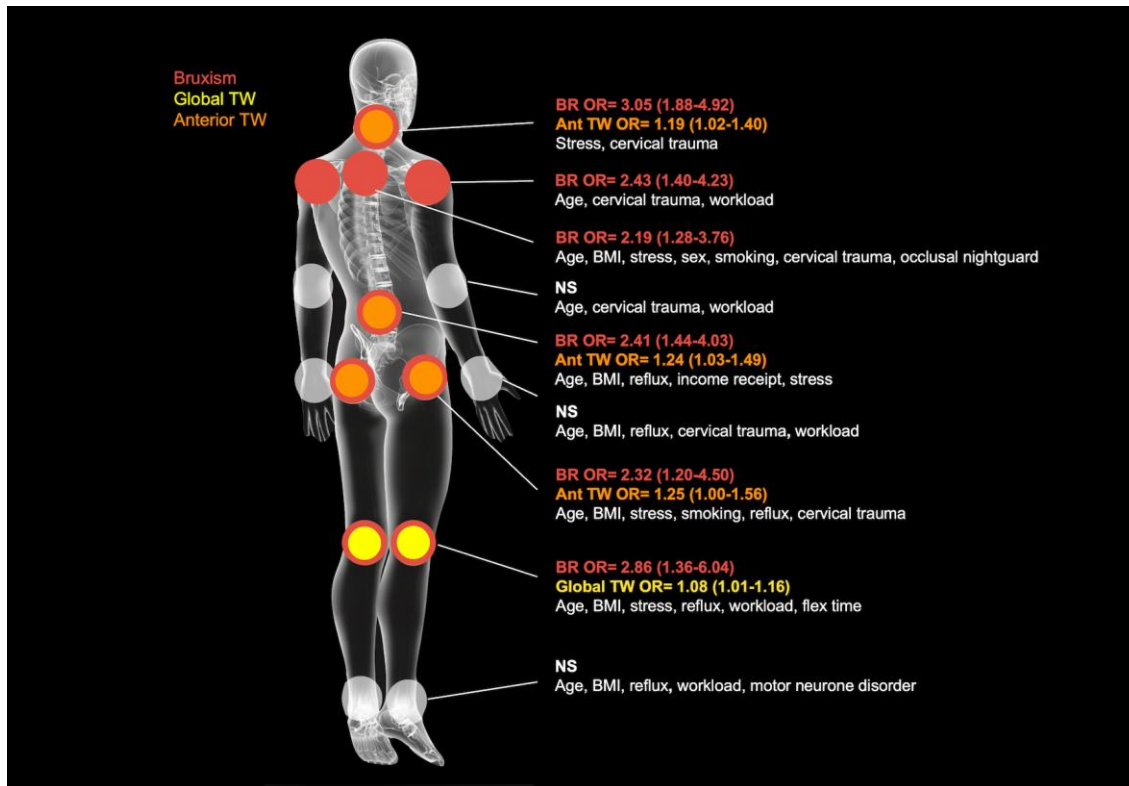


Figure 2 Pictures of a young bruxer patient showing an early stage of TW, with only a few mild facets of enamel attrition in the anterior area. This mechanical TW is combined to a dental fissure on #41 and masseter hypertrophy characteristic of BR, which she reports. This Figure shows that BR activity is not proportional to the amount of hard tissue loss while a mechanical TW limited to the anterior area is typical of BR involving mandibular thrust.