

# Association Between Primary Headache and Bruxism: An Updated Systematic Review

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**Aims:** To answer the question: among observational studies, is there any association between primary headaches and bruxism in adults? **Materials and Methods:** A systematic review of observational studies was performed. The search was performed in seven main databases and three gray literature databases. Studies in which samples were composed of adult patients were included. Primary headaches were required to be diagnosed by the International Classification of Headache Disorders. Any diagnostic method for bruxism was accepted. Risk of bias was evaluated using the Joanna Briggs Institute Critical Appraisal Tool and the Meta-Analysis of Statistics Assessment and Review Instrument (MAStARI) tool. Associations were analyzed by calculating odds ratios (OR) in Review Manager 5.3 software. The evidence certainty was screened by Grading of Recommendations Assessment, Development, and Evaluation criteria. **Results:** Of the 544 articles reviewed, 5 met the inclusion criteria for qualitative analysis. The included studies evaluated both awake and sleep bruxism, as well as tension-type headaches and migraines as primary headaches. Among two migraine studies, one showed an OR of 1.79 (95% CI: 0.96 to 3.33) and another 1.97 (95% CI: 1.5 to 2.55). On the other hand, among three tension-type headache studies, there was a positive association only with awake bruxism, with an OR of 5.23 (95% CI: 2.57 to 10.65). All included articles had a positive answer for more than 60% of the risk of bias questions. The evidence certainty varied between low and very low. Due to high heterogeneity among the studies, it was impossible to perform a meta-analysis. **Conclusion:** Patients with awake bruxism have from 5 to 17 times more chance of having tension-type headaches. Sleep bruxism did not have any association with tension-type headache, and the association with migraines is controversial. *J Oral Facial Pain Headache 2021;35:129–138. doi: 10.11607/ofph.2745*

**Keywords:** *bruxism, primary headache disorders, migraine disorders, systematic review, tension-type headache*

Primary headaches are commonly classified as tension-type headache (TTH), migraine, cluster headache, and other primary trigeminal cephalalgias.<sup>1</sup> TTH is the most prevalent form of primary headache, with a prevalence of around 30%.<sup>2,3</sup> Of people with TTH, 60% show a decrease in work performance and social activities.<sup>4</sup> Migraines are also common, with 1 in every 10 people worldwide suffering from migraines.<sup>5</sup> The prevalence of migraines in Europe is 11.4%, and in North America is 9.7%.<sup>5</sup> Because of their prevalence, TTH and migraines are considered to be worldwide neurologic disorders.<sup>6</sup>

Studies regarding both of these primary headaches (TTH and migraine) have suggested that dysfunction of the masticatory and cervical muscles, as well as psychosocial factors, can be associated with an increased prevalence of both types of headache.<sup>7,8</sup> In addition, headaches are considered one of the symptoms of bruxism.<sup>9</sup>

Bruxism is a condition or a behavior that has clinically undesirable consequences or that can contribute as a risk factor for any of them.<sup>10,11</sup> Bruxism can be categorized as sleep or awake bruxism. Sleep bruxism is characterized as a sleep activity of the masticatory muscles, further characterized as rhythmic (phasic) and nonrhythmic (tonic) movements, while awake bruxism is characterized as a repetitive or sustained ac-

tivity by contact of tooth and/or contraction of muscles during the day.<sup>10</sup> Despite the different definitions, bruxism does not always cause adverse effects, since the mandibular movement improves the passage of the airways and stimulates the production of saliva, which is a protection factor.<sup>10,12</sup> According to a recent publication,<sup>12</sup> bruxism can be classified as “normo-bruxism,” when it has no associated harmful signs and symptoms, or as “patho-bruxism,” when there are pathologic impacts on the bruxist.<sup>13</sup>

Regarding the diagnosis of bruxism, a consensus of international experts categorized bruxism according to the method used to detect it.<sup>10</sup> In this consensus, both bruxism types were categorized as possible bruxism (by questionnaires or self-report), as probable (by clinical assessment), or as definitive by electromyography (EMG) or polysomnography (PSG), which are the reference standards.<sup>10</sup>

The prevalence of self-reported sleep bruxism is estimated to be approximately 12.8% ( $\pm$  3.1%) of the adult population.<sup>14</sup> However, considering PSG exclusively as a diagnostic method, the prevalence lowers to 7.4%.<sup>15</sup> The prevalence of possible awake bruxism is 20% for tooth contact and 14% for mandible bracing.<sup>16</sup> Due to the high cost and low availability of EMG recordings up to now, there is no prevalence of definitive awake bruxism in the literature.<sup>14</sup>

Several studies have tried to identify the association between bruxism and headaches.<sup>9,17,18</sup> This knowledge can help doctors develop a better treatment plan. A previous systematic review published in 2014<sup>9</sup> reported the presence of an association between sleep bruxism and both migraine and TTH. However, since 2014, new studies on this topic and a new edition of headache guidelines have been published. Thus, this systematic review aims to update knowledge on the following question: Among observational studies, is there any association between primary headaches and bruxism in adults?

## Materials and Methods

A systematic review protocol based on the Preferred Reporting Items for Systematic Review and Analysis Protocols (PRISMA-p) was prepared.<sup>19</sup> The protocol was registered at the International Prospective Register of Systematic Reviews (PROSPERO) under number CRD42018109698. This systematic review was reported according to the PRISMA guidelines.<sup>20</sup>

### Eligibility Criteria

#### Inclusion criteria

The inclusion criteria were specified using the PECOS approach:

1. Population: adult sample ( $\geq$  18 years of age)
2. Exposition: awake or sleep bruxism diagnosed by any method
3. Comparison: primary headaches (migraine, TTH, cluster headache, paroxysmal hemicrania, and trigeminal autonomic cephalalgias) diagnosed by The International Classification of Headache Disorders (ICHD), any edition
4. Outcome: association between primary headaches and bruxism (awake and/or sleep)
5. Study design: observational studies (analytical cross-sectional, case-control, and descriptive)

The included studies were from all languages without gender restriction or year of publication. If required, translation help was sought.

### Exclusion Criteria

The exclusion criteria were: (1) studies that did not associate bruxism and primary headaches; (2) book chapters, conference abstracts, expert opinion, letters, and literature/systematic reviews; (3) samples that consisted only of patients with temporomandibular disorders (TMD); (4) studies that did not diagnose primary headaches using ICHD criteria; (5) duplicate samples of previous included studies; (6) studies that did not have a control group (without bruxism and/or without primary headache); and (7) studies without bruxism classification (awake or sleep).

### Information Sources and Search Strategy

The individual search strategies were developed with the help of a specialized librarian. The strategy was applied in each bibliographic database, including Embase, Latin American and Caribbean Health Sciences (LILACS), LIVIVO, PsycINFO, PubMed (including Medline), Scopus, and Web of Science. Additionally, gray literature was searched on Google Scholar, OpenGrey, and ProQuest Dissertation and Thesis. The search was performed on April 13, 2020 (Appendix 1; see all appendices in the online version of this article at [www.quintpub.com/journals](http://www.quintpub.com/journals)). A hand search of the references of all included articles was also done. Additionally, an email was sent to authors who had more than five published articles identified in phase 1 requesting suggestions of new articles for possible inclusion. All references were managed on appropriate software (Rayyan), and duplicates were removed (EndNote X9).

### Study Selection

The selection of included studies was completed in two phases, both performed by the same two authors (J.C.R. and H.P.). In phase 1, the two authors independently read and evaluated the titles and abstracts of all studies and defined the studies included for the next phase. In phase 2, they read the full texts

to confirm their eligibility. Any disagreement in both phases was resolved by means of discussion. If no consensus was achieved, a third author (B.D.M.S.) participated until an agreement was reached.

### Data Extraction

One author (J.C.R.) collected the main information from the selected studies. A second author (H.P.) crosschecked the collected information and confirmed its accuracy. Once again, any disagreement was resolved by discussion between the authors. A third author (B.D.M.S.) was involved when required to make a final decision about the inclusion of articles.

The following data were collected from the included studies: author, year, country, study design, sample (male/female), sample source, bruxism type, bruxism diagnosis method, primary headache type, primary headache diagnosis method, and main conclusions. If required data were incomplete, attempts were made to contact the corresponding authors by email to retrieve any missing information. Two emails were sent to corresponding authors for missing information.

### Risk of Bias in Individual Studies and Across Studies

The risk of bias of selected studies was evaluated using the Critical Appraisal Tool of the Joanna Briggs Institute and the Meta-Analysis of Statistics Assessment and Review Instrument (MAStARI)<sup>21,22</sup> for analytical cross-sectional, case-control, and/or descriptive studies, depending on the included study design. Two authors (J.C.R. and H.P.) independently evaluated each domain in terms of the potential risk of bias. Questionnaires consisted of questions with the possible answers of "yes," "no," "unclear," or "not applicable." The authors crosschecked their evaluations and, in case of disagreement on each question, a third author (B.D.M.S.) was involved to discuss and mediate. The presence or absence of confounding factors was the main point that was evaluated across studies. A greater weight was considered in this question when assessing the risk of bias.

### Summary Measures and Synthesis of Results

The main outcome assessed was the association between bruxism and primary headaches. The summary measure considered odds ratios (OR) with 95% CI for dichotomous variables.

Although the data were too heterogenous to perform a meta-analysis, the results were presented in forest plots created with the aid of Review Manager 5.3 software (RevMan 5.3) provided by the Cochrane Collaboration to better clarify the data.

### Confidence in Cumulative Evidence

A summary of the overall strength of evidence available was presented and divided by groups analyzed using the GRADE (Grading of Recommendations Assessment, Development and Evaluation) criteria. The GRADE tool was applied according to groups of outcomes. Summary of findings tables were produced with the aid of the GRADE online software (GRADEpro GTD).<sup>23</sup>

## Results

### Study Selection

The search in the main databases resulted in 1,152 citations. After removing duplicate citations, the titles and abstracts of 544 articles were evaluated in phase 1 using the eligibility criteria. Thereafter, 511 studies were excluded, resulting in a final number of 33 articles to be assessed in phase 2. No studies were selected from the gray literature, 1 study was obtained from experts, and 4 were obtained from the reference lists of the studies included in phase 1. Therefore, phase 2 consisted of 38 articles. From these remaining studies, 33 were later excluded (Appendix 2), resulting in only 5 studies for qualitative analyses. A flowchart summarizing this systematic selection process is shown in Fig 1.

### Study Characteristics

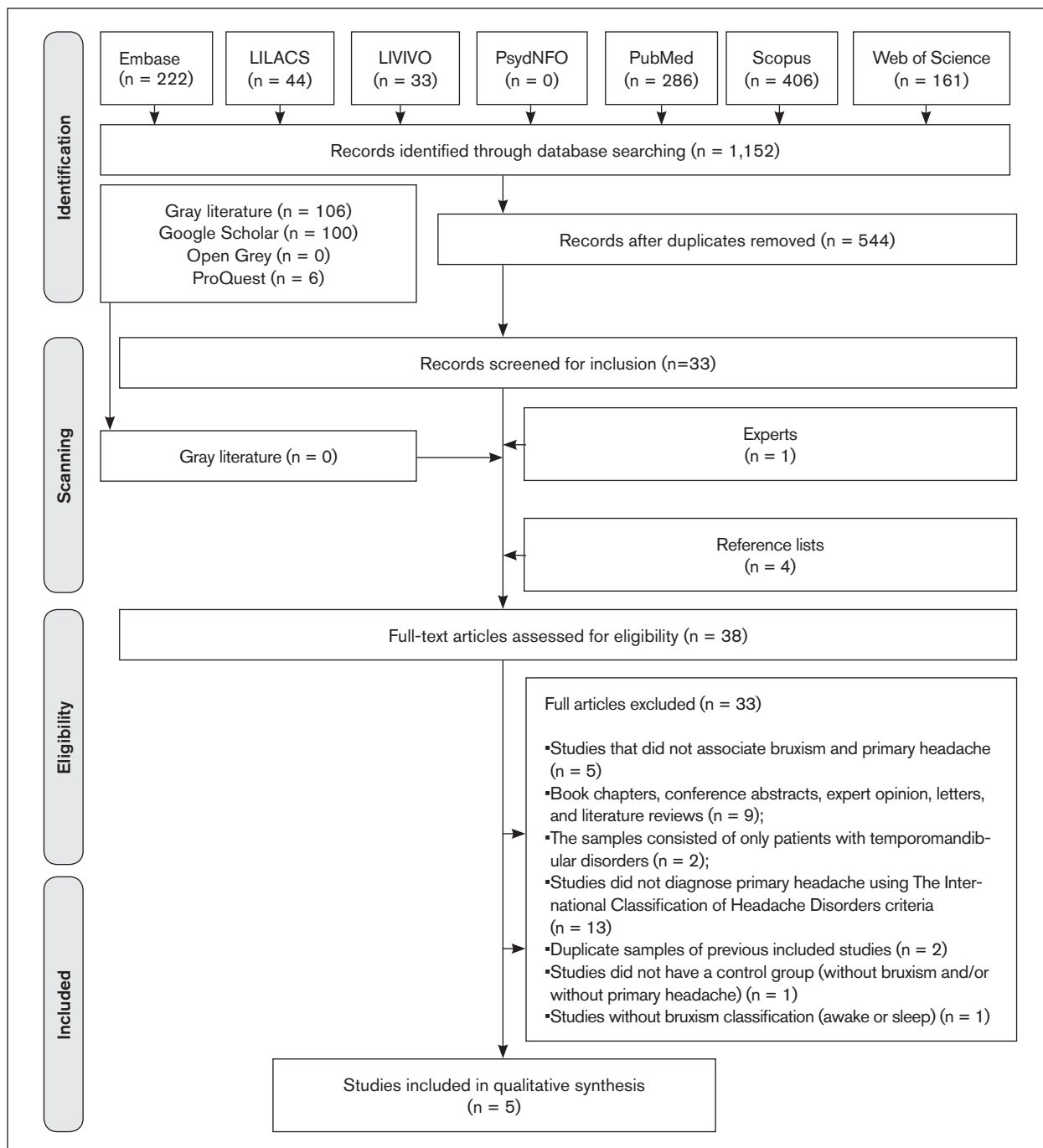
The included studies were observational studies (analytical cross-sectional and descriptive) conducted in four countries: Brazil,<sup>24,25</sup> Denmark,<sup>26</sup> Germany,<sup>27</sup> and Saudi Arabia.<sup>28</sup> The samples ranged from 115<sup>26</sup> to 3,853<sup>28</sup> patients. Among bruxism types, the majority of the articles evaluated sleep bruxism,<sup>24-28</sup> and only 1 evaluated awake bruxism.<sup>25</sup> Regarding the types of primary headaches, only migraines<sup>24,27,28</sup> and TTH<sup>24-27</sup> were identified. More information about the included studies can be found in Table 1.

### Risk of Bias Within Studies

Among two analytical cross-sectional studies, one<sup>25</sup> was positive for all risk of bias questions, and another<sup>26</sup> for 62.5% of the answers. Similarly, among three descriptive studies, one<sup>24</sup> was positive for 87.5% of the answers, and the other two<sup>27,28</sup> had 62.5%. Appendix 3 presents detailed information on the risk of bias assessment.

### Results of Individual Studies

Fernandes et al<sup>24</sup> recruited patients aged 18 to 76 years from São Paulo State University (UNESP), School of Dentistry, Araraquara. The authors analyzed the overall sample and a fraction of this sample without TMD. Sleep bruxism was diagnosed by



**Fig 1** Flowchart of literature search and selection criteria.

self-report and clinical assessment according to the American Association of Sleep Medicine (AASM). In the overall sample of 286 individuals, 87 sleep bruxers (26.4% with TTH and 73.6% with migraines) and 64 without sleep bruxism (28.1% with TTH and 71.9% with migraines) had primary headaches, and 36 individuals did not suffer sleep bruxism or primary headache. Among the individuals without TMD (66 individuals), 5 with sleep bruxism (40% with TTH and 60% with migraines) and 24 without sleep brux-

ism (37.5% with TTH and 62.5% with migraines) had primary headaches; and 23 individuals did not suffer sleep bruxism or primary headaches.

Muayqil et al<sup>28</sup> distributed a survey link through email to all King Saud University members. Sleep bruxism was diagnosed via questionnaire. Of participants who responded to the questions about headaches (mean age of  $32.3 \pm 14$  years) and sleep bruxism, 358 had sleep bruxism (case group) and 1,466 did not (control group). In the case group,

**Table 1 Summary of Characteristics of Included Articles (n = 5)**

Study, year, country	Study design	Sample, n (men/women)	Sample source	Bruxism type	Bruxism diagnosis method	Primary headache type	Primary headache diagnosis method	Main conclusion
Fernandes et al, <sup>24</sup> 2013, Brazil	Descriptive	286 (45/241)	TMD and Orofacial Pain Clinic at São Paulo State University (UNESP), School of Dentistry, Araraquara	Sleep bruxism	Self-report + clinical assessment from AASM	TTH and migraine	ICHD-2	SB did not have an association with episodic TTH or episodic migraine
Muayqil et al, <sup>28</sup> 2018, Saudi Arabia	Descriptive	3,853 (NR)	King Saud University students, faculty and non-faculty staff	Sleep bruxism	One question	Migraine	ICHD-3	Bruxers had 1.97 (95% CI: 1.53 to 2.55) greater odds of migraine.
Troeltzsch et al, <sup>27</sup> 2011, Germany	Descriptive	1,031 (436/595)	Patients of an oral and maxillofacial surgery practice in Ansbach	Sleep bruxism	Self-report + physical exam	TTH, migraine and both	ICHD-1	Bruxers had 10.47 (95% CI: 5.45 to 10.12) greater odds of primary headaches.
Wagner et al, <sup>25</sup> 2019, Brazil	Analytical cross-sectional	162 (76/86)	Military firefighters Department of the State of Rio de Janeiro	Sleep bruxism Awake bruxism	Questionnaire (ICSD-3) + clinical assessment Question 15d of RDC	TTH TTH	ICHD-3 ICHD-3	SB without TMD complaints did not increase the association with frequent TTH. Awake bruxism had an association with TTH with nonpainful TMDs.
Yachida et al, <sup>26</sup> 2012, Denmark	Analytical cross-sectional	115 (39/76)	Danish Headache Center, Glostrup Hospital, Denmark	Sleep bruxism	Self-report	TTH	ICHD-2	There was no significant difference between TTH with and without SB.

TTH = tension-type headache; ICHD = International Classification of Headache Disorders; AASM = American Association of Sleep Medicine; ICSD = International Classification of Sleep Disorders; NR = not reported; RDC = Research Diagnostic Criteria.

73.2% of sleep bruxism patients had migraines; and among the control group, 58% had migraines. A total of 615 patients were not diagnosed with migraine or sleep bruxism.

Troeltzsch et al<sup>27</sup> recruited the study population (mean age of 49.6 years) from an oral and maxillofacial surgery practice in Ansbach, Germany. Sleep bruxism was diagnosed by self-report and clinical assessment. After clinical assessment, 696 patients were diagnosed with primary headache: 71% with TTH, 13% with migraines, 12% with both, and 4% with others. Among this primary headache sample, 25.8% had sleep bruxism (self-reported plus incisal/premolar/molar wear). Of the 336 individuals without primary headaches (control group), 3% had sleep bruxism.

Wagner et al<sup>25</sup> included 162 participants aged 18 to 55 years from military firefighters. Like Fernandes et al,<sup>24</sup> the authors analyzed the overall sample and a fraction without TMD. In the overall sample, 61.5% of 26 sleep bruxers and 47.8% of 136 people without sleep bruxism had primary headaches. Of the TMD-free patients, among the 9 individuals with sleep bruxism and 81 without sleep bruxism, 11.1% and 21% had primary headaches, respectively. In the overall awake bruxism sample (59 individuals), 74.5%

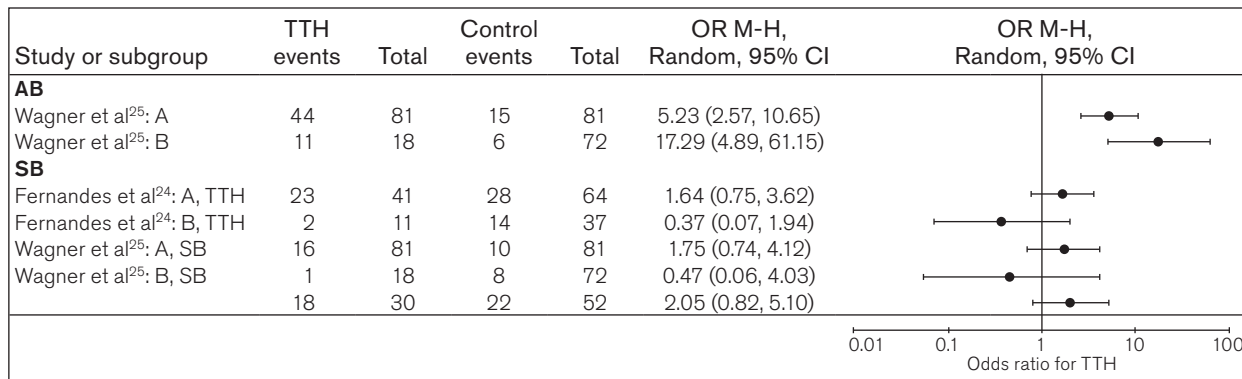
had primary headaches. Of the 17 TMD-free patients, 64.7% had primary headaches.

Yachida et al<sup>26</sup> recruited patients from Aarhus University, Denmark; patients who responded to flyers and newspaper advertisements; patients at the same university; and from the Danish Headache Center, Glostrup Hospital, Denmark. From 72 patients of the sleep bruxism group, 25% had TTH; and from 43 individuals in the control group (without sleep bruxism), approximately 28% had sleep bruxism. A total of 30 patients were not diagnosed with sleep bruxism or TTH.

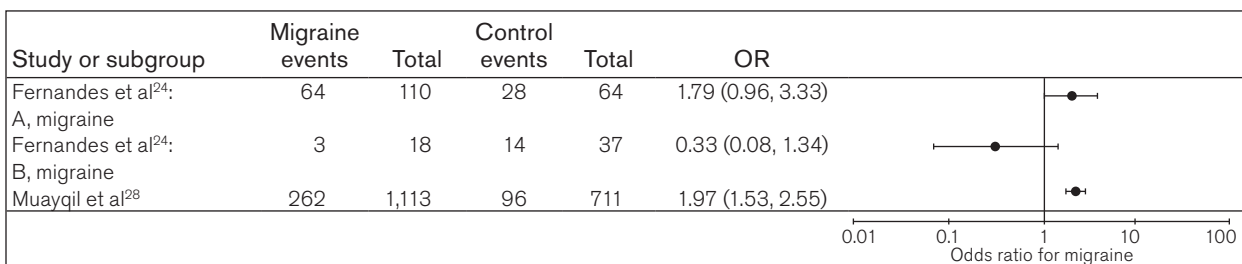
### Synthesis of Results

The heterogeneity of the included studies did not justify a meta-analysis due to the authors using different methodologies for diagnosing bruxism. Figures 2 and 3 were generated to illustrate and better showcase the results of each study and to visually assess differences in their outcomes.

The studies were grouped according to the outcomes. The studies of Fernandes et al<sup>24</sup> and Wagner et al<sup>25</sup> were each divided into two (A and B) because they provided the overall sample information (A) and the sample without TMD (B).



**Fig 2** Analysis of tension-type headache (TTH) patients with bruxism. AB = awake bruxism; SB = sleep bruxism; OR = odds ratio; A = sample with possibility of having TMD; B = sample without TMD.



**Fig 3** Analysis of migraine patients with bruxism. AB = awake bruxism; SB = sleep bruxism; OR = odds ratio; A = sample with possibility of having TMD; B = sample without TMD.

The Troeltzsch et al<sup>27</sup> study was removed from the analysis because it was not possible to separate the data between TTH and migraines.

To more easily interpret the results, the analysis was performed according to the primary headache classification and the type of bruxism.

**TTH vs Awake Bruxism**

In the overall sample,<sup>25</sup> patients with concomitant awake bruxism and TMD had 5.23 (95% CI: 2.57 to 10.65; n = 162) greater odds of developing TTH (Fig 2). In the same sense, patients with awake bruxism without TMD had 17.29 (95% CI: 4.89 to 61.15; n = 90) greater odds of developing TTH.

**TTH vs Sleep Bruxism**

None of the studies showed an association between TTH and sleep bruxism (Fig 2). The overall sample and the TMD-free samples of Fernandes et al<sup>24</sup> presented an OR of 1.64 (95% CI: 0.75 to 3.62; n = 105) and an OR of 0.37 (95% CI: 0.07 to 1.94; n = 48), respectively. Wagner et al<sup>25</sup> reported an OR of 1.75 (95% CI: 0.74 to 4.12; n = 162) and an OR of 0.47 (95% CI: 0.06 to 4.03; n = 90) in the overall sample and the TMD-free sample, respectively. Yachida et al<sup>26</sup> found an OR of 2.05 (95% CI: 0.82 to 5.10; n = 82).

**Migraine vs Sleep Bruxism**

Only one study showed a positive association between migraines and sleep bruxism, with an OR of 1.97 (95% CI: 1.53 to 2.55; n = 2,824; Fig 3).<sup>28</sup> Neither sample (overall and TMD-free) of Fernandes et al<sup>24</sup> showed a positive association. The authors found an OR of 1.79 (95% CI: 0.96 to 3.33; n = 174) for the overall sample and 0.33 (95% CI: 0.08 to 1.34; n = 56) for the TMD-free sample.

**Risk of Bias Across Studies**

There were two reasons for downgrading the risk of bias. The first was due to bruxism diagnosis, which only two studies<sup>24,25</sup> screened using validated methods. Only articles that diagnosed bruxism with self-report/questionnaires plus clinical assessment (probable bruxism) were considered to be low risk of bias. Another reason was that there were confounding factors that were not taken into consideration in most of the articles.

**Confidence in Cumulative Evidence**

The GRADE evaluation was done according to bruxism type. The certainty of evidence was low in sleep bruxism and very low in awake bruxism groups. The main reasons for downgrading the assessment for both bruxism groups were the observational study design and the inability to perform a meta-analysis. For awake bruxism, another limitation was the small sample size. More information can be found in Table 2.

**Table 2 GRADE Summary of Findings Table**

No. of participants	Study design	Quality assessment				Other considerations	Quality
		Risk of bias	Inconsistency	Indirectness	Imprecision		
<b>Sleep bruxism</b>							
1,594 (5 observational studies)	Cross-sectional	Serious <sup>a</sup>	Very serious <sup>b</sup>	Not serious	Serious	Very strong association  All plausible residual confounding would reduce the demonstrated effect dose response gradient	⊕⊕○○ Low
<b>Awake bruxism</b>							
162 (1 observational study)	Cross-sectional	Not serious	Very serious <sup>b</sup>	Not serious	Very serious <sup>c</sup>	All plausible residual confounding would reduce the demonstrated effect dose response gradient	⊕○○○ Very low

<sup>a</sup>The majority of studies had positive answers to around 60% of the risk of bias questions.

<sup>b</sup>No meta-analysis

<sup>c</sup>Sample size smaller than 200.

## Discussion

This systematic review investigated the association between primary headaches and bruxism. Five articles were included, and both sleep and awake bruxism were evaluated. Regarding primary headache type, only studies that identified migraines and TTH were found in the literature.

The studies included in this systematic review showed a positive association between awake bruxism and TTH, but not between sleep bruxism and TTH. One study<sup>28</sup> showed a positive association between sleep bruxism and migraines, and another<sup>24</sup> did not. These findings agree with previously published articles.<sup>17,18</sup>

This systematic review is an update of another study published in 2014.<sup>9</sup> The main differences between the first systematic review<sup>9</sup> and the present one are that the present eligibility criteria are broader to include awake bruxism, any diagnostic criteria of bruxism, and any type of primary headache, not just TTH and migraines. The reason for this change was to include research studies regarding other types of primary headaches, even though this resulted in more studies to review. Notwithstanding the broader criteria, most included studies evaluated sleep bruxism with the same primary headache types as explained in the previous systematic review.<sup>9</sup> The main contribution of this updated systematic review is the inclusion of three new included articles,<sup>25,26,28</sup> with one<sup>25</sup> that specifically evaluated awake bruxism.

The intent was to include all primary headaches in this review, but in fact, only TTH and migraines were mentioned in the included articles. This is most likely due to their higher prevalence. A literature review pub-

lished in 2007<sup>29</sup> showed a worldwide prevalence of 42% for TTH and 11% for migraines, contrasting with chronic headaches, which only showed a prevalence of 3%. Other primary headache types are trigeminal autonomic cephalalgias (TACs), including cluster headache, paroxysmal hemicrania, short-lasting unilateral neuralgiform headache attacks, and hemicrania continua.<sup>1</sup> Although cluster headache is the most prevalent of the TACs, it is a condition that affects only 0.1% of the general population.<sup>30</sup> Besides this very low prevalence, the diagnosis of cluster headache often has a delay due to the fact that the pain period and pain-remission periods are interchangeable.<sup>1</sup>

Only the ICHD was accepted as the diagnostic method for primary headaches, but it has three editions, and the updates have important changes that could affect the diagnostic process. Troeltzsch et al<sup>27</sup> used the first edition,<sup>31</sup> so it is uncertain if the primary headaches had enough of the correct characteristics for the right diagnoses. According to the explanation of Jen Olesen,<sup>32</sup> the first edition was performed based on expert opinion, which was relevant for that time, but not for today. The second edition<sup>33</sup> included expert opinion based on scientific evidence, and half of the studies included in this review used it for diagnoses.<sup>24,26</sup> The beta version of the third edition<sup>34</sup> was used by the remaining two included studies.<sup>25,28</sup> The difference between the second and third editions is the inclusion of the International Classification of Disease in the last edition, making each updated edition more reliable for clinicians and researchers.

For many years, both sleep and awake bruxism were associated with TTH.<sup>35,36</sup> However, in this systematic review where they were evaluated separately, only awake bruxism showed an association with TTH,<sup>25</sup> which provides an excellent contribution to diagnosis.

This association likely happens due to the persistent daytime clenching, which increases tension in the masticatory muscles.<sup>37,38</sup> This tension, over time, results in the sensitization of peripheral muscle nociceptors that might change the stimulus-response function, explaining the abnormal stimulus-response function in patients.<sup>39–41</sup> Further, according to Buchgreitz et al,<sup>42</sup> the displacement of the stimulus-response function is closely associated with the frequency of headaches in those who suffer from TTH.

On the other hand, sleep bruxism was associated with migraines in one study.<sup>28</sup> This could be explained by some body mechanisms. When patients clench, grind, or bite their teeth, the masticatory muscles may develop inflammation sites and consequently pain.<sup>43</sup> The presence of proinflammatory factors contributes to the activation of the trigeminal nucleus caudalis.<sup>44</sup> Thus, this change results in the production of nerve impulses, and the pain information is conducted by afferent nerve fibers into the brain, where nociceptor inputs are stimulated, causing head pain.<sup>43,44</sup> However, another included study<sup>24</sup> did not show a positive association, making the association questionable.

### Limitations

Methodologic limitations should be considered when discussing the present results. In this systematic review, some included studies diagnosed bruxism by only self-report or questionnaires,<sup>25,26,28</sup> and others by clinical assessment as well.<sup>24,25,27</sup> However, none diagnosed bruxism by PSG. This heterogeneity is a limitation in itself, including the inconsistency in clinical assessments and questionnaires. There were also incidental findings mentioned, such as tooth wear,<sup>24,27</sup> tongue and cheek biting,<sup>27</sup> and myalgia and hypertrophy.<sup>24,25</sup> Besides that, awake bruxism was diagnosed by only one question, making its reliability questionable. In addition to the possibility of categorizing bruxism according to diagnostic method (possible, probable, and definitive)<sup>10</sup> to reduce heterogeneity, future research should adopt a validated diagnostic method for more consistent results.

Only one article<sup>25</sup> evaluated both sleep and awake bruxism. The awake bruxism group showed an association with primary headaches, while the sleep bruxism group did not. According to Lavigne and Palla,<sup>45</sup> sleep bruxism episodes are phasic and do not cause pain, while only few tonic or sustained contractions (awake bruxism) may cause pain. This is a serious bias on the results, since the definitions and consequences of two bruxism types are very different.<sup>10</sup> This potentially raises an important question as to whether the presence of primary headache is a consequence of sleep bruxism only, or if awake bruxism also had an influence on this association. In addition, caution must be taken when extrapolating the results

pertaining to awake bruxism, since only one included article<sup>25</sup> evaluated this type of bruxism.

## Conclusions

With low and very low levels of evidence, it can be concluded that:

- Patients with awake bruxism appear to have from 5 to 17 times more chance of having TTH. Patients with sleep bruxism have the same chance of having TTH as controls. The association between sleep bruxism and migraines is controversial.
- There is a need for well-designed case-control studies with larger samples and valid and homogenous bruxism diagnoses to strengthen the conclusions related to this association.

## Highlights

- Awake bruxism is associated with TTH.
- There are no studies associating awake bruxism and migraines.
- Sleep bruxism is not associated with TTH.
- The association between sleep bruxism and migraines is questionable.
- Only migraines and TTH were evaluated as primary headaches in this association.

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and design; data analysis; methodology; project administration; software; supervision; drafting and critical revision of manuscript for important intellectual content and for submission.

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## Appendix 1 Database Search Strategy

Database	Search (April 2020)
Embase	(bruxism':ti,ab,kw OR 'sleep bruxism':ti,ab,kw OR 'awake bruxism':ti,ab,kw OR 'diurnal bruxism':ti,ab,kw) AND ('primary headache disorders':ti,ab,kw OR 'primary headache':ti,ab,kw OR 'headache':ti,ab,kw OR 'migraine disorders':ti,ab,kw OR 'migraine':ti,ab,kw OR 'tension-type':ti,ab,kw OR 'headache':ti,ab,kw OR 'trigeminal autonomic cephalalgias':ti,ab,kw OR 'cephalgia':ti,ab,kw OR 'cephalalgia':ti,ab,kw OR 'cluster headache':ti,ab,kw OR 'paroxysmal hemicrania':ti,ab,kw)
LILACS	(tw:(bruxismo OR "bruxismo do sono" OR "bruxismo em vigília" OR "brujo nocturno" OR brujería OR bruxism OR "sleep bruxism" OR "awake bruxism" OR "diurnal bruxism")) AND (tw:(“dor de cabeça” OR “dor de cabeça primária” OR enxaqueca OR cefaleia OR “cefaleia tensional” OR “dolor de cabeza” OR “trastornos primarios de dolor de cabeza” OR migraña OR cefalea OR “cefalea tensional” OR “primary headache disorders” OR “primary headache” OR “headache” OR “migraine disorders” OR migraine OR tension-type OR headache OR “trigeminal autonomic cephalalgias” OR cephalgia OR cephalgia OR “cluster headache” OR “paroxysmal hemicrania”))
LIVIVO	(bruxism OR “sleep bruxism” OR “awake bruxism” OR “diurnal bruxism”) AND (“primary headache” OR migraine OR “tension-type headache” OR “cluster headache” OR cephalalgia OR “paroxysmal hemicrania”)
PsycINFO	(bruxism AND headache)
PubMed	(bruxism[MeSH Terms] OR “sleep bruxism”[MeSH Terms] OR bruxism[All Fields] OR bruxer[All Fields] OR bruxers[All Fields] OR “awake bruxism”[All Fields] OR “diurnal bruxism”[All Fields]) AND (“headache disorders, primary”[MeSH Terms] OR “primary headache”[All Fields] OR “headache”[MeSH Terms] OR headache[Text Word] OR “migraine disorders”[MeSH Terms] OR migraine[Text Word] OR “tension-type headache”[MeSH Terms] OR “Tension-type headache”[Text Word] OR “trigeminal autonomic cephalalgias”[MeSH Terms] OR “Trigeminal autonomic cephalalgias”[Text Word] OR cephalgia[Text Word] OR cephalalgia[Text Word] OR “cluster headache”[MeSH Terms] OR “cluster headache”[All Fields] OR “paroxysmal hemicrania”[MeSH Terms] OR “paroxysmal hemicrania”[All Fields])
Scopus	TITLE-ABS-KEY ( bruxism OR “sleep bruxism” OR “awake bruxism” OR “diurnal bruxism” ) AND TITLE-ABS-KEY ( “primary headache disorders” OR “primary headache” OR “headache” OR “migraine disorders” OR migraine OR tension-type OR “trigeminal autonomic cephalalgias” OR cephalgia OR cephalgia OR “cluster headache” OR “paroxysmal hemicrania” ) AND ( LIMIT-TO ( DOCTYPE , “ar” ) OR LIMIT-TO ( DOCTYPE , “ip” ) )
Web of Science	TS=(bruxism OR “sleep bruxism” OR “awake bruxism” OR “diurnal bruxism”) AND TS=(“primary headache disorders” OR “primary headache” OR “headache” OR “migraine disorders” OR migraine OR tension-type OR “trigeminal autonomic cephalalgias” OR cephalgia OR cephalgia OR “cluster headache” OR “paroxysmal hemicrania”)
Google Scholar	(headache OR migraine OR “primary headache” OR “cluster headache”) AND (bruxism OR “sleep bruxism” OR “awake bruxism”)
OpenGrey	(headache OR migraine OR “primary headache” OR “cluster headache”) AND (bruxism OR “sleep bruxism” OR “awake bruxism”)
ProQuest	(headache OR migraine OR “primary headache” OR “cluster headache”) AND (bruxism OR “sleep bruxism” OR “awake bruxism”)

## Appendix 2 Excluded Articles and Reasons for Exclusion (n = 33)

Study, year	Reason for exclusion
Alves et al, 2013 <sup>1</sup>	1
Caspersen et al, 2011 <sup>2</sup>	2
Costa et al, 2008 <sup>3</sup>	3
Costa et al, 2016 <sup>4</sup>	1
D'Ippolito et al, 2010 <sup>5</sup>	1
de Siqueira et al, 2015 <sup>6</sup>	4
Didier et al, 2014 <sup>7</sup>	4
Fernandes, 2011 <sup>8</sup>	5
Giannasi et al, 2010 <sup>9</sup>	2
Huynh et al, 2006 <sup>10</sup>	2
Jalilzadeh et al, 2010 <sup>11</sup>	2
Kato et al, 2014 <sup>12</sup>	2
Kato et al, 2016 <sup>13</sup>	6
Köhler, 2012 <sup>14</sup>	4
La Mantia et al, 2018 <sup>15</sup>	1
Lafveskans, 2008 <sup>16</sup>	2
Lavigne, 2014 <sup>17</sup>	2
Lucchesi et al, 2010 <sup>18</sup>	4
Marklund et al, 2014 <sup>19</sup>	4
Molina et al, 1997 <sup>20</sup>	4
Molina et al, 2011 <sup>21</sup>	4
Moss, 1984 <sup>22</sup>	4
Moss et al, 1989 <sup>23</sup>	4
Nekora-Azak et al, 2010 <sup>24</sup>	4
Peşkersoy et al, 2016 <sup>25</sup>	7
Porporatti et al, 2015 <sup>26</sup>	3
Scher et al, 2003 <sup>27</sup>	4
Seidel et al, 2009 <sup>28</sup>	4
Siqueira et al, 2009 <sup>29</sup>	2
Steele et al, 1991 <sup>30</sup>	4
Wagner and Moreira Filho, 2018 <sup>31</sup>	5
Wieselmann et al, 1987 <sup>32</sup>	2
Winocur et al, 2001 <sup>33</sup>	1

1 = studies that did not associate bruxism and primary headache; 2 = book chapters, conference abstracts, expert opinion, letters, and literature/systematic reviews; 3 = study samples that consisted of only patients with temporomandibular disorders (TMD); 4 = studies that did not diagnose primary headache using The International Classification of Headache Disorders criteria; 5 = duplicate sample of previous included studies; 6 = studies did not have a control group (without bruxism and/or without primary headache); 7 = studies without bruxism classification (awake or sleep).

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### Appendix 3a Risk of Bias Assessed with the Joanna Briggs Institute/MAStARI Critical Appraisal Tool for Analytical Cross-Sectional Studies

Question	Wagner et al, <sup>25</sup> 2019	Yachida et al, <sup>26</sup> 2012
1. Were the criteria for inclusion in the sample clearly defined?	+	+
2. Were the study subjects and the setting described in detail?	+	-
3. Was the exposure measured in a valid and reliable way?	+	-
4. Were objective, standard criteria used for measurement of the condition?	+	-
5. Were confounding factors identified?	+	+
6. Were strategies to deal with confounding factors stated?	+	+
7. Were the outcomes measured in a valid and reliable way?	+	+
8. Was appropriate statistical analysis used?	+	+
<b>% yes/risk</b>	<b>100</b>	<b>62.5</b>
+ = yes; - = no; NA = not applicable.		

### Appendix 3b Risk of Bias Assessed with the Joanna Briggs Institute/MAStARI Critical Appraisal Tool for Descriptive Studies

Question	Muayqil et al, <sup>28</sup> 2018	Fernandes et al, <sup>24</sup> 2013	Troeltzsch et al, <sup>27</sup> 2011
1. Was study based on a random or pseudo-random sample?	+	-	+
2. Were the criteria for inclusion in the sample clearly defined?	+	+	+
3. Were confounding factors identified and strategies to deal with them stated?	-	+	-
4. Were outcomes assessed using objective criteria?	-	+	-
5. If comparisons are being made, was there a sufficient description of the groups?	-	+	-
6. Was follow-up carried out over a sufficient time period?	NA	NA	NA
7. Were the outcomes of people who withdrew described and included in the analysis?	+	+	+
8. Were outcomes measured in a reliable way?	+	+	+
9. Was appropriate statistical analysis used?	+	+	+
<b>% yes/risk</b>	<b>62.5</b>	<b>87.5</b>	<b>62.5</b>
+ = yes; - = no; NA = not applicable.			