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REVIEW

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Subjective sleep quality and temporomandibular disorders: Systematic literature review and meta-analysis

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Abstract

Study objectives: To assess the general subjective sleep quality in individuals with and without TMD, and its distribution among the TMD diagnostic groups.

Methods: A systematic review search was performed in Pubmed/MEDLINE, Embase, LILACS, Web of Science, SciELO, CINAHL and Cochrane Central as well as in the grey literature. Observational studies published since 1992 which used either the DC/TMD or RDC/TMD for TMD diagnosis and either the PSQI, SAQ or ESS questionnaires for sleep assessment were included. Articles selected for meta-analysis underwent quality, heterogeneity and publication bias evaluation.

Results: A total of 1071 articles were found by online search, and 10 articles were added manually. For full-text reading, 138 papers were selected. Thirty-six articles were included in the final review, and 19 in the meta-analysis (PSQI only). Subjective sleep quality was shown to be associated with all RDC/TMD or DC/TMD Axis I diagnostic groups: muscle disorders, arthralgia/osteoarthritis/osteoarthrosis and disk displacements; with the highest association in the first two groups, and the lowest in the last one. A 4.45 times increased odds ratio of TMD prevalence was found for individuals who presented poor subjective sleep quality.

Conclusion: Subjective sleep quality should be considered in the management of TMD.

KEYWORDS

meta-analysis, sleep quality, systematic review, temporomandibular disorders, TMD

1 | INTRODUCTION

According to the American Academy of Orofacial Pain (AAOP), temporomandibular disorders (TMD) are a set of pathological conditions characterised by pain or limitation of movement in the temporomandibular joint(s) (TMJ), the masticatory muscles or both.[1,2] The main functional, physical and psychosocial consequences of TMD may significantly impair oral health and quality of life.[2,3] It is a multifactorial condition triggered by initiating co-factors: existing pain conditions, trauma, parafunction or emotional distress, which affect the stomatognathic system's homeostasis.[4]

The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) was published in 1992 and has been the standard diagnostic tool for TMD until 2014, when the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) was published.[5,6] The TMD chronic pain is frequently related to other chronic pain conditions (ie tension headaches, fibromyalgia, chronic fatigue and irritable bowel syndrome) and present neuroendocrine abnormalities, biopsychosocial distress, fatigue, impaired sleep quality, anxiety and/or depression.[7]

Sleep quality and TMD relationship have been studied since 1995.[6] It was found that mandibular pain was twice as high in

individuals who presented sleep disorders when compared to those who were asymptomatic. The existence of a direct relationship between pain intensity and poor sleep quality has been reported.[8,9] The Pittsburgh Sleep Quality Index (PSQI), the Sleep Assessment Questionnaire (SAQ) and the Epworth Sleepiness Scale (ESS) have been the most widely used diagnostic questionnaires for subjective sleep quality assessment in TMD patients.[7]

Experimental studies have indicated a reciprocal relationship between pain and disturbed sleep.[10] The decrease in total sleep hours and the interference in REM sleep favours musculoskeletal pain and can reduce pain thresholds as well as increase pain sensitivity. Cohort and case-control studies report significant association between obstructive sleep apnoea syndrome (OSAS) and TMD.[10] Individuals who were diagnosed with sleep disorders presented five times increased odds ratio for TMD development.[8,9] Insomnia can be a predictor of chronic pain, and it has been associated with exacerbation of clinical pain and psychological distress.[11]

It has been hypothesised that TMD patients usually present poor sleep quality. As meta-analytic information on the topic has not been published yet, the present study aimed to identify the relationship between subjective sleep quality and TMD by a systematic review and meta-analysis. The objectives were to analyse sleep quality in individuals who do and do not suffer from TMD as well as to verify its distribution in the different diagnostic groups according to the RDC/TMD and DC/TMD axes I and II.

2 | METHODS

2.1 | Study design

A systematic review and meta-analysis were performed according to the Meta-Analyses of Observational Studies in Epidemiology (MOOSE) Guidelines[12] and the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA).[13] The research protocol was registered at PROSPERO database (ID: CRD42018109382). Online search was carried out using the following databases: Pubmed/MEDLINE, Embase, LILACS, Web of Science, SciELO, CINAHL and Cochrane Central. Grey literature search was performed on ProQuest, Google Scholar, NDLTD/Global EDT Search, and Brazilian Digital Library of Thesis and Dissertations (BDTD). Manual search was conducted in the references from selected articles. This project was approved by the Research Ethics Committee of the School of Health Sciences, Program in Dentistry, Pontifical Catholic University of Rio Grande do Sul – PUCRS (2018: SIPESQ #7965).

2.2 | Research question

The review process was structured to answer a central PICOS[14] question: "Is there any difference in subjective sleep quality between individuals who do and do not present TMD?" Where P (population) refers to individuals over 16 years old; I (intervention) refers to TMD individuals; C (control) refers to individuals who do not present TMD; O (outcome) refers to subjective sleep quality; and S (study type) refers to cross-sectional and/or analytical studies (ie cohort and case-control).

2.3 | Search strategy

Two search strings were developed based on the PubMed/Medline Medical Subject Heading (MeSH) and on the BIREME Health Sciences Boolean Terms (DeCS) according to each database requirements. No other filters or limitations were applied (Table 1).

2.4 | Inclusion and exclusion criteria

The study selection was carried out by two researchers independently. All database searches were exported to EndNote (Clarivate®, EUA). The software automatically excluded duplicates, and the reviewers repeated the same process manually.

Papers were selected according to the inclusion and exclusion criteria. Inclusion criteria were clinical or population, descriptive or analytical observational studies which have investigated sleep quality in the presence and absence of TMD in subjects with 16 years of age or higher, published since 1992. Studies must have used either the PSQI, SAQ or ESS for sleep quality assessment, and either the RDC/TMD or DC/TMD for TMD diagnosis. Only studies that used the PSQI were considered for meta-analysis. There were no idiomatic restrictions. Exclusion criteria were case reports, case series, letters, comments, short communications, animal and in vitro studies. In addition, individuals who underwent irreversible TMD treatments (ie orthodontic and/or surgical treatments) and who had a history of face trauma were also excluded. Finally, articles that used other diagnostic tools for TMD and sleep quality assessment and that included patients who used medication which could interfere in sleep quality were also excluded.

2.5 | Study selection and extraction of data

The systematic review was conducted by two researchers, one MSc and one PhD student from PUCRS Post-Graduate Program in Dentistry, independently. The study selection was conducted in two phases: (a) title and abstract reading, when the paper was selected by at least one of the researchers; and (b) full-text reading, when the final selection depended on the agreement between the two researchers. If needed, a third researcher was invited, a professor from PUCRS Post-Graduate Program in Dentistry. Studies that were published in unknown languages were translated using online tools (ie Google Translator). Data were extracted to an Excel (Microsoft Corporation) spreadsheet according to the Cochrane Manual for Systematic Reviews.[15] Data were classified as general information (ie title, publication year, journal,

TABLE 1 General Boolean terms for search in the different databases

MeSH search string	DeCS search string
((‘Temporomandibular Disorders’ OR ‘Disorder, Temporomandibular Joint’ OR ‘Disorders, Temporomandibular Joint’ OR ‘Joint Disorder, Temporomandibular’ OR ‘Joint Disorders, Temporomandibular’ OR ‘Temporomandibular Joint Disorder’ OR ‘TMJ Disorders’ OR ‘Disorder, TMJ’ OR ‘Disorders, TMJ’ OR ‘TMJ Disorder’ OR ‘Temporomandibular Disorders’ OR ‘Disorder, Temporomandibular’ OR ‘Disorders, Temporomandibular’ OR ‘Temporomandibular Disorder’ OR ‘Temporomandibular Joint Diseases’ OR ‘Disease, Temporomandibular Joint’ OR ‘Diseases, Temporomandibular Joint’ OR ‘Joint Disease, Temporomandibular’ OR ‘Joint Diseases, Temporomandibular’ OR ‘Temporomandibular Joint Disease’ OR ‘TMJ Diseases’ OR ‘Disease, TMJ’ OR ‘Diseases, TMJ’ OR ‘TMJ Disease’) **AND** (‘Disorder, Sleep Wake’ OR ‘Disorders, Sleep Wake’ OR ‘Sleep Wake Disorder’ OR ‘Wake Disorder, Sleep’ OR ‘Wake Disorders, Sleep’ OR ‘Subwakefullness Syndrome’ OR ‘Subwakefullness Syndromes’ OR ‘Syndrome, Subwakefullness’ OR ‘Syndromes, Subwakefullness’ OR ‘Sleep Disorders’ OR ‘Disorder, Sleep’ OR ‘Disorders, Sleep’ OR ‘Sleep Disorder’ OR ‘Sleep-Related Neurogenic Tachypnea’ OR ‘Neurogenic Tachypnea, Sleep-Related’ OR ‘NeurogenicTachypneas, Sleep-Related’ OR ‘Sleep Related Neurogenic Tachypnea’ OR ‘Sleep-Related Neurogenic Tachypneas’ OR ‘Tachypnea, Sleep-Related Neurogenic’ OR ‘Tachypneas, Sleep-Related Neurogenic’ OR ‘Long Sleeper Syndrome’ OR ‘Long Sleeper Syndromes’ OR ‘Sleeper Syndrome, Long’ OR ‘Sleeper Syndromes, Long’ OR ‘Syndrome, Long Sleeper’ OR ‘Syndromes, Long Sleeper’ OR ‘Short Sleeper Syndrome’ OR ‘Short Sleeper Syndromes’ OR ‘Sleeper Syndrome, Short’ OR ‘Sleeper Syndromes, Short’ OR ‘Syndrome, Short Sleeper’ OR ‘Syndromes, Short Sleeper’ OR ‘Short Sleep Phenotype’ OR ‘Phenotype, Short Sleep’ OR ‘Phenotypes, Short Sleep’ OR ‘Short Sleep Phenotypes’ OR ‘Sleep Phenotypes, Short’))	((‘Temporomandibular Joint Diseases’ OR ‘TMJ Diseases’ OR ‘Temporomandibular Disorders’ OR ‘Temporomandibular Joint Diseases’ OR ‘Disease, TMJ’ OR ‘Disease, Temporomandibular Joint’ OR ‘Diseases, TMJ’ OR ‘Diseases, Temporomandibular Joint’ OR ‘Disorder, TMJ’ OR ‘Disorder, Temporomandibular’ OR ‘Disorder, Temporomandibular Joint’ OR ‘Disorders, TMJ’ OR ‘Disorders, Temporomandibular’ OR ‘Disorders, Temporomandibular Joint’ OR ‘Joint Disease, Temporomandibular’ OR ‘Joint Diseases, Temporomandibular’ OR ‘Joint Disorder, Temporomandibular’ OR ‘Joint Disorders, Temporomandibular’ OR ‘TMJ Disease’ OR ‘TMJ Disorder’ OR ‘Temporomandibular Disorder’ OR ‘Temporomandibular Joint Disease’ OR ‘Temporomandibular Joint Disorder’ OR ‘TMJ Disorders’ OR ‘Temporomandibular Joint Dysfunction Syndrome’ OR ‘Costen's Syndrome’ OR ‘Costen Syndrome’ OR ‘Consten's Syndrome’ OR ‘Joint Syndrome, Temporomandibular’ OR ‘Syndrome, Costen's’ OR ‘Syndrome, TMJ’ OR ‘Syndrome, Temporomandibular Joint’ OR ‘Myofascial Pain Dysfunction Syndrome, Temporomandibular Joint’ OR ‘TMJ Syndrome’ OR ‘Temporomandibular Joint Syndrome’) **AND** (‘Sleep Wake Disorders’ OR ‘Long Sleeper Syndrome’ OR ‘Short Sleep Phenotype’ OR ‘Short Sleeper Syndrome’ OR ‘Sleep-Related Neurogenic Tachypnea’ OR ‘Subwakefullness Syndrome’ OR ‘Disorder, Sleep’ OR ‘Disorder, Sleep Wake’ OR ‘Disorders, Sleep’ OR ‘Disorders, Sleep Wake’ OR ‘Long Sleeper Syndromes’ OR ‘Neurogenic Tachypnea, Sleep-Related’ OR ‘Neurogenic Tachypneas, Sleep-Related’ OR ‘Phenotype, Short Sleep’ OR ‘Phenotypes, Short Sleep’ OR ‘Short Sleep Phenotypes’ OR ‘Short Sleep Syndromes’ OR ‘Sleep Disorder’ OR ‘Sleep Phenotypes, Short’ OR ‘Sleep Related Neurogenic Tachypnea’ OR ‘Sleep Wake Disorder’ OR ‘Sleep-Related Neurogenic Tachypneas’ OR ‘Sleeper Syndrome, Long’ OR ‘Sleeper Syndrome, Short’ OR ‘Sleeper Syndromes, Long’ OR ‘Sleeper Syndromes, Short’ OR ‘Subwakefullness Syndromes’ OR ‘Syndrome, Long Sleeper’ OR ‘Syndrome, Short Sleeper’ OR ‘Syndrome, Subwakefullness’ OR ‘Syndromes, Long Sleeper’ OR ‘Syndromes, Short Sleeper’ OR ‘Syndromes, Subwakefullness’ OR ‘Tachypnea, Sleep-Related Neurogenic’ OR ‘Tachypneas, Sleep-Related Neurogenic’ OR ‘Wake Disorder, Sleep’ OR ‘Wake Disorders, Sleep’ OR ‘Sleep Disorders’))

authors and countries); methods (ie study design, assessment criteria for TMD, assessment criteria for sleep quality, data collection, study duration and statistical analysis); sample (ie sample selection, sample size, sex and mean age); TMD (ie RDC/TMD or DC/TMD scores); and sleep quality (ie PSQI, SAQ and/or ESS scores).

2.6 | Statistical and data analysis

Qualitative analysis was carried out on the selected papers for meta-analysis according to the Newcastle-Ottawa Scale (NOS).[16] Stars were attributed for quality level in three different criteria: selection, comparability and outcome. The more stars given, the higher the article quality.

The data underwent heterogeneity assessment by means of the I-square test (I^2). Heterogeneity was considered to be low when the results ranged between 0% and 25%, intermediate between 25% and 75%, and high at 75% or higher.[17]

The quantitative analysis was performed by means of forest plots using a meta-analytic approach. The random-effects model was used ($p < .05$). The odds ratio (OR) was used for risk indicator analysis in categorical data, while the raw difference of means was used for continuous data (R statistical software version 4.0.4, with meta package version 4.18–0[18]). All studies were presented descriptively in the systematic review.

3 | RESULTS

The final number of articles found in each database was the following: (a) Pubmed/MEDLINE = 391, (b) Embase = 229, (c) LILACS = 137, (d) Web Of Science = 29, (e) SciELO = 10, (f) CINAHL = 156, (g) Cochrane Central = 10, (h) ProQuest = 20, (i) Google Scholar = 77, (j) NDLTD = 3 and (k) BDTD = 9. A total of 648 studies were retrieved after online, grey literature and manual searches, as well as after duplicates were removed. The PRISMA[13] flowchart of study selection is shown in Figure 1. Thirty-six articles were included after full-text reading in the systematic review. Twenty-five were found by online search, four by grey literature search, and seven studies were included after manual search; unpublished studies were considered as

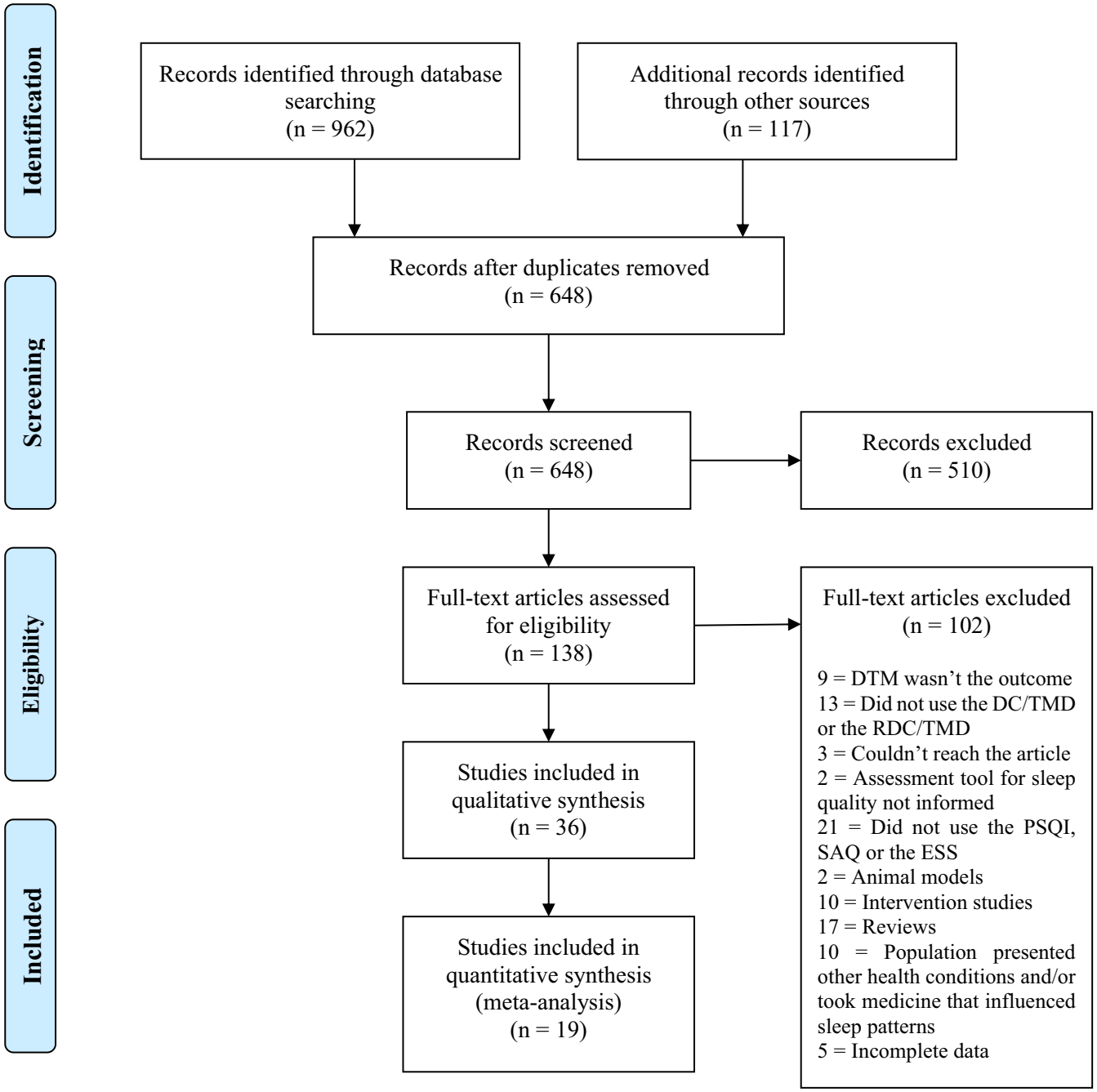

FIGURE 1 PRISMA flow diagram for identification and selection of the included and excluded studies in the systematic review and meta-analysis

grey literature. The most important information about the selected studies is shown in Tables 2 and 3. Out of the 36 selected articles for systematic review, only 19 were included in both the qualitative assessment and meta-analysis (Table 4, Figures 2 and 3).

The oldest article was published in 2002. Most of the selected papers were published since 2012. Fourteen different countries were included (ie Brazil,[9,19–27] Canada,[22,25,28,29] China,[30–33] Germany,[34] Greece,[35] Israel,[36] Japan,[37] Holland,[32] Slovenia,[38,39] South Korea,[40] Singapore,[30,33] Sweden,[28,41] Turkey[42,43] and the USA[10,11,28,29,35–37,39,44–51]). Most studies (n=31)[10,11,19–21,23,24,27–31,33–51] used the PSQI for subjective sleep quality assessment, and the RDC/TMD for TMD assessment (n = 28)[9–11,19–23,25–27,30,34,35,37–40,42–44,46–51]; therefore, the results of this review reflected mostly these two research instrument findings.

Sample sizes ranged from 30 to 1643 subjects, but only two papers investigated more than 1000 people.[26,47] Women were more often assessed than men, and eight studies were conducted only with women.[9,20,22,28,29,34,40,45] Mean age ranged between 15.56 and 47.65 years old. Twelve studies were excluded for the meta-analysis due to the lack of sleep and/or TMD data for the control groups,[10,1

TABLE 2 Description of the selected studies for the systematic review which used either the Diagnostic Criteria (DC/TMD) or the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) to assess TMD and its association with sleep quality. *N* = 36

First Author (Year) [Reference]	*N*	Country	TMD/nTMD Sample size	Gender	TMD diagnosis	Sleep disorders diagnosis
Alattar (2016)[41]	37	Sweden	37/0	6 (M) 31 (F)	DC/TMD (Axis I G1 and Axis II)	PSQI
Benoliel et al. (2017)[36]	286	USA, Israel	187/99	139 (M) 157(F)	DC/TMD (Axis I)	PSQI
Bertoli et al, (2007)[44]	445	USA	445/0	42 (M) 403 (F)	RDC/TMD (Axis I G1 G3)	PSQI
Buenaver et al. (2012)[35]	214	USA, Greece	214/0	55 (M) 159 (F)	RDC/TMD (Axis I)	PSQI
Daher et al. (2018)[19]	40	Brazil	25/15	7 (M) 33 (F)	RDC/TMD (Axis I G1 G3)	PSQI
Dias et al. (2015)[20]	45	Brazil	32/13	0 (M) 45 (F)	RDC/TMD (Axis I) and CT scans	PSQI
Drabovicz et al. (2012)[21]	200	Brazil	71/129	105 (M) 95 (F)	RDC/TMD (Axis I)	PSQI
Dubrovsky et al. (2017)[28]	170	USA, Canada, Sweden	124/46	0 (M) 170 (F)	RDC/TMD (Axis I, G1)	PSQI
Eisenlohr-Moul et al. (2015)[45]	43	USA	17/16	0 (M) 43 (F)	DC/TMD(Axis I)	PSQI
Ekici, Ö. (2021)[43]	464	Turkey	464/0	80 (M) 384 (F)	RDC/TMD (Axis not specified)	PSQI
Fillingim et al. (2011)[47]	1688	USA	171/1517	708 (M) 922 (F)	RDC/TMD (Axis not specified)	PSQI
Grossi et al. (2008)[22]	55	Canada, Brazil	44/11	0 (M) 55 (F)	RDC/TMD (Axis I)	SAQ
de Leeuw et al. (2005)[48]	110	USA	55/55	4 (M) 106 (F)	RDC/TMD (Axis not specified)	PSQI
Lei et al. (2016)[30]	578	China, Singapore	355/223	371 (M) 207 (F)	DC/TMD (Axis not specified)	CPSQI
Lei et al. (2016)[31]	755	China	181/574	172 (M) 583 (F)	RDC/TMD (Axis I)	CPSQI
Lindroth et al. (2002)[49]	574	USA	574/0	69 (M) 505 (F)	RDC/TMD (Axis I G1 G3)	PSQI
Moana-Filho & Babiloni (2019)[29]	39	Canada, USA	22/17	0 (M) 39 (F)	DC/TMD (Axis I G1)	PSQI
Park & Chung (2016)[40]	60	South Korea	40/20	0 (M) 60 (F)	RDC/TMD (Axis II)	PSQI, ESS
Peixoto (2016)[23]	91	Brazil	43/48	20 (M) 71 (F)	RDC/TMD (Axis I)	PSQI
Peixoto et al. (2021)[24]	638	Brazil	156/482	163 (M) 475 (F)	DC/TMD (Axis not specified)	PSQI
Porto et al. (2011)[50]	81	USA	81/0	22 (M) 59 (F)	RDC/TMD (Axis I, G1)	PSQI
Rehm et al. (2012)[25]	30	Brazil, Canada	30/0	4 (M) 26 (F)	RDC/TMD (Axis I and II)	SAQ
Rehm et al. (2020)[26]	1643	Brazil	AI G1: 484/1159AI G2:126/1517AI G3:470/1173AII: 595/1048	560 (M) 1083 (F)	RDC/TMD (Axis I and II)	SAQ

(Continues)

TABLE 2 (Continued)

First Author (Year) [Reference]	*N*	Country	TMD/nTMD Sample size	Gender	TMD diagnosis	Sleep disorders diagnosis
Rener-Sitar et al. (2014)[38]	609	Slovenia	496/113	91 (M) 518 (F)	RDC/TMD (Axis I G1 G3)	PSQI
Rener-Sitar et al. (2016)[39]	700	USA, Slovenia	609/91	105 (M) 595 (F)	RDC/TMD (Axis I and II)	PSQI
Ribeiro-Dasilva et al. (2012)[46]	119	USA	49/70	54 (M) 65 (F)	RDC/TMD (Axis not specified)	PSQI
Sanders et al. (2013)[10]	1761	USA	-	-	RDC/TMD (Axis I G1 and G3)	PSQI
Schmitter et al. (2015)[34]	44	Germany	22/22	0 (M) 44 (F)	RDC/TMD (Axis I G1 and Axis II)	PSQI
Selaimen et al. (2006)[9]	102	Brazil	72/30	0 (M) 102 (F)	RDC/TMD (Axis I G1 G3)	SAQ
Şener & Guler (2012)[42]	194	Turkey	130/64	81 (M) 13 (F)	RDC/TMD (Axis I G1 G2)	PSQI
Smith et al. (2009)[11]	53	USA	53/0	26 (M) 27 (F)	RDC/TMD (Axis I G1)	PSQI@@@ESS
Sousa (2015)[27]	100	Brazil	50/50	20 (M) 80 (F)	RDC/TMD (Axis I)	PSQI
Su et al. (2016)[32]	320	China, Holland	84/236	70 (M) 250 (F)	DC/TMD(Axis I)	ESS
Vazquez-Delgado et al. (2004)[51]	201	USA	201/0	39 (M) 162 (F)	RDC/TMD (Axis I G1 G2+G3)	PSQI
Yap et al. (2021)[33]	961	China, Singapore	845/116	200 (M) 761 (F)	DC/TMD (Axis I G1 G2 G3)	PSQI
Yatani et al. (2002)[37]	137	USA, Japan	137/0	13 (M) 124 (F)	RDC/TMD (Axis I G1 G3)	PSQI

Abbreviations: DC/TMD, diagnostic criteria for temporomandibular disorders; ESS, Epworth Sleepiness Scale; F, female; G1, muscular disorders; G2, disk displacements; G3, arthralgias; M, male; nTMD, controls; PSQI, Pittsburgh Sleep Quality Index; RDC/TMD, Research diagnostic criteria for temporomandibular disorders; SAQ, Sleep Assessment Questionnaire; TMD, temporomandibular disorder patients.

[1,24,35,37,38,41,43,44,49–51] four studies were excluded because the PSQI was not used for sleep quality assessment,[9,22,26,32] and one study was excluded for both reasons.[25]

The meta-analysis was divided according to the different DC or RDC/TMD diagnostic groups and type of data: (a) TMD diagnosis (ie no axis or group division) using continuous data (Figure 2); (b) TMD diagnosis (ie no axis or group division) using categorical data (Figure 3); (c) Axis II using continuous data (Figure 4); (d) Axis I group 1 division only (ie muscle disorders) using continuous data (Figure 5); (e) Axis I group 2 (ie disk displacements) using continuous data (Figure 5) and (f) Axis I group 3 using continuous data (ie arthralgia/osteoarthritis/osteoarthrosis) (Figure 5). Figures 2 and 3 combine Axes I and II since many studies did not clarify which RDC/TMD or DC/TMD section was used.

It can be observed that patients with TMD do have worse (ie higher scores) levels of subjective sleep quality than those without it, in both continuous and categorical analyses (Figures 2 and 3), and in both RDC/TMD Axes I and II classifications (Figures 4 and 5). In addition, in the categorical analysis (Figure 3), poor subjective sleep quality increases the odds ratio of having TMD in more than four times (OR = 4.45). In Figure 5, the level of association between the RDC/TMD Axis I classification (ie groups 1, 2 and 3) with poor subjective sleep quality was based on the highest mean difference to the lowest: (a) group 1 (ie muscles disorders) = 3.03, (b) group 3 (ie arthralgia/osteoarthrosis/osteoarthritis) = 2.59 and (c) group 2 (ie disk displacements) = 1.10. Groups 1 and 3 presented mean differences twice as high as group 2.

Quality analysis by the NOS can be found in Table 4. In all studies, the bias assessment yielded low results, showing that the articles selected for the meta-analysis were from good to excellent quality (ie five stars or more).

4 | DISCUSSION

Review articles addressing sleep and TMD have been already published; however, meta-analyses were not performed.[52–55] A systematic review concerning sleep and TMD was published in 2013 by Veiga et al.[55] All selected articles (n = 13) reported that TMD patients had poorer sleep quality, regardless of the assessment criteria. A more recent systematic review,[52] which studied the association between painful TMD and sleep quality, reported 8 studies which presented

TABLE 3 Summary of the results and conclusions of the selected studies for the systematic review which used either the Diagnostic Criteria (DC/TMD) or the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) to assess TMD and its association with sleep quality. *N* = 36

First Author (Year) [Reference]	Results/Conclusions
Alattar (2016)[41]	All patients were diagnosed with masticatory muscle myalgia, 75% reported poor sleep quality. Pain intensity, pain-related disability, depression, anxiety, stress, catastrophising, and number of masticatory muscle pain sites were related to poor sleep quality ($p = .031$).
Benoliel et al. (2017)[36]	TMD patients were classified as masticatory muscle disorder (MMD), isolated TMJ disorders (TMJ) and both (TMP). PSQI global score for the whole TMD (MMD, TMJ and TMP) group was 5.53 (2.85). Control group presented a global PSQI score of 4.41 (2.64) ($p = .001$). No significant PSQI differences were found between the TMD diagnostic groups.
Bertoliet al. (2007)[44]	Patients were divided into masticatory muscular (MM) pain and TMJ pain diagnostic groups. PSQI total score for MM group was 10 (4.4) and TMJ group was 8 (4.2) ($p = .000$). Positive-PTSD (post-traumatic stress disorder) subgroups of both MM and TMJ groups presented higher levels of sleep disturbance compared to non-PTSD subgroups ($p < .05$).
Buenaver et al. (2012)[35]	All patients were diagnosed with myofascial TMD (89% alone, 5.6% with disk displacement and 3.7% with joint involvement). The PSQI global score was 7.6 (4.0). Pain catastrophising was associated with sleep disorders. The rumination component of catastrophising was related to TMD through sleep disturbance. Reducing pain catastrophising may improve sleep patterns and clinical pain.
Daher et al. (2018)[19]	TMD patients with either muscular or articular disorders presented worse sleep quality when compared to the control group ($p < .05$). PSQI global score for articular TMD (n=10) and muscular TMD ($n = 15$) were 8.35 (4.20) and 10.20 (5.53), respectively. The control group scored 3.54 (0.53). Lower levels of pain threshold and anxiety were also associated with the presence of TMD.
Dias et al. (2015)[20]	75.6% individuals presented poor sleep quality ($n = 34$). Among them, 67% had degenerative condylar bone changes. Between the good sleep quality group ($n = 11$), 81.8% had some type of degenerative bone changes. There was no statistical difference between sleep patterns and degenerative changes ($p = .36$).
Drabovicz et al. (2012)[21]	The PSQI global score for TMD individuals ($n = 71$) was 7.3 and for non-TMD ($n = 129$) was 4.3. The presence of TMD was statistically associated with poor sleep quality ($p < .001$).
Dubrovsky et al. (2017)[28]	TMD cases had significantly higher PSQI scores when compared to controls. Depressive symptoms were also statistically associated (both $p < .001$).
Ekici, Ö. (2021)[43]	The author assessed anxiety, depression, and sleep quality in bruxer and non-bruxer TMD patients. No TMD-free control group was reported. The PSQI global score for the TMD with sleep bruxism group was 6.64 (3.417) and 6.10 (3.267) for the TMD without sleep bruxism group. The groups were not statistically different ($p = .145$), however, results indicate poor sleep quality in both groups (global PSQI score over 5.0). The study also reported that the bruxism rate increased as the anxiety and depression levels increased.
Eisenlohr-Moul et al. (2015)[45]	The PSQI global score for the TMD group was 10.41 (3.35) and for the control group was 9.40 (2.50), which did not present statistical differences ($p > .05$). When analysing patients who presented TMD +fibromyalgia (FM), there was statistical difference from controls and from TMD only group. The PSQI score for TMD+FM was 13.18 (3.62).
Fillingim et al. (2011)[47]	The study presents data from the OPPERA Cohort Study. The PSQI global score for TMD cases was 6.5 (3.8), and for the control group was 4.7 (3.0). TMD patients reported poorer sleep quality when compared to controls.
Grossi et al. (2008)[22]	The SAQ score for TMD patients was 21.6 (6.7) and for the control group was 11 (4.7) ($p < .05$). Non-responding TMD patients had higher levels of depression, sleep disorders and fatigue, and lower levels of energy when compared to responding TMD patients.
de Leeuw et al. (2005)[48]	The PSQI total score for TMD patients was 8.69 (4.38) and for the control group was 5.44 (3.21). As $p = .000$, there is a statistically significant relationship between TMD and sleep disturbance.
Lei et al. (2016)[30]	The CPSQI total score for the TMD group was 5.91 (2.59), which was statistically significant when compared to the control group's 4.65 (2.91) ($p < 0.01$). TMD patients had higher psychological distress and disturbed sleep when compared to sound individuals.
Lei et al. (2016)[31]	The study provided data concerning myofascial pain and non-myofascial pain patients. The CPSQI total score for the myofascial pain group was 7.62 (3.15) and for the control group was 5.42 (3.15) ($p < .01$). Disturbed sleep, anxiety and stress were possible risk indicators for myofascial pain.
Lindroth et al. (2002)[49]	The study reported sleep quality data in TMD masticatory muscle pain (MMP) and intracapsular pain (ICP) patients. The PSQI total score for the MMP group was 11.1 (4.5) and for the ICP group was 9.9 (4.4). Both diagnostic groups presented poor sleep quality, but MMP group was statistically worse ($p = .01$).
Moana-Filho & Babiloni (2019)[29]	Only female individuals were accessed. PSQI global score for the TMD group (myalgia) was 7.7 (4.2), while the control group presented a PSQI global score of 4.0 (2.4) ($p = .002$). In this study, other poor sleep quality, TMD cases also presented statistically significant greater depression and anxiety levels, perceived stress, jaw function limitation, somatic symptoms severity and oral parafunctional habits.
Park & Chung (2016)[40]	TMD patients were divided into having low or high disability according to the GCPS. When comparing the high disability group and the matching controls, the study reported a PSQI total score of 11.40 (3.42) and an ESS total score of 9.74 (1.42) for the TMD patients and a PSQI total score of 3.75 (2.15) and ESS total score of 6.35 (0.87) for the controls ($p = .000$).

(Continues)

TABLE 3 (Continued)

First Author (Year) [Reference]	Results/Conclusions
Peixoto (2016)[23]	The study provided de % of TMD and TMD-free patients who suffered from sleep disorders. Within the 43 TMD patients assessed, 32 (74.42%) reported sleep disturbance (PSQI global score ≥5). 50% of the TMD-free patients presented impaired sleep, which was statistically significant when compared to the TMD cases ($p = .017$).
Peixoto et al. (2021)[24]	The study identified 93.4% individuals as poor sleepers (PSQI >5.0). Worse subjective sleep quality presented higher levels of TMD symptoms ($p<0.001$, OR=3.01). PSQI global scores for TMD and TMD-free participants were not reported, which justifies the absence of this paper in the meta-analysis.
Porto et al. (2011)[50]	The PSQI global score for masticatory muscle pain (MMP) group was 10.19 (4.11). There was no control group. The MMP group was compared to an idiopathic continuous or facial neuropathic pain (ICONP), which presented a PSQI global score of 9.76 (4.81). There was no statistical difference between both groups ($p = .540$).
Rehm et al. (2012)[25]	This study assessed sleep quality in TMD patients who also presented sleep bruxism, before and after being treated with a bite splint. The baseline SAQ score (before treatment) was 16.1 (10.0) and the SAQ score after treatment was 15.9 (9.9). There was no statistical difference between the two assessments ($p > .05$).
Rehm et al. (2020)[26]	This population study presents SAQ scores for cases and controls within all RDC/TMD diagnostic groups. Axis I G1 reported a SAQ total score of 22.38 (10.45) for cases and 15.98 (8.27) for controls ($p < .001$). Axis I G2 presented a SAQ global score of 18.66 (9.71) for cases and 17.80 (9.40) for controls (non-significant). Axis I G3 reported a SAQ total score of 21.52 (10.63) for cases and 16.40 (8.47) for controls ($p < .001$). Axis II presented a SAQ global score of 21.82 (9.95) for cases and 15.62 (8.32) for controls ($p < .001$). TMD patients had worse sleep quality, particularly in the higher pain diagnostic groups.
Rener-Sitar et al. (2014)[38]	The PSQI global score for pain-related TMD cases was 7.1 (4.0), while the pain-free patients scored 5.1 (3.1). *p*-value was not informed. Sleep quality in TMD patients is a unidimensional construct and can be represented by the PSQI summary score.
Rener-Sitar et al. (2016)[39]	This study reported a PSQI total score of 7.0 (4.0) for TMD cases (no diagnostic group specification) and 5.2 (3.2) for controls ($p < .05$). The authors also presented the PSQI global scores for each RDC/TMD diagnostic group: Axis I G1 8.1 (7.5), Axis I G2 5.4 (7.0), Axis I G3 5.7 (7.2). For Axis II, according to the GCPS: grade 0–4.7, grade 1–6.5, grade 2–7.7, grade 3–11.2, grade 4–10.5. Sleep quality should always be assessed when managing TMD patients, especially the ones with pain-related diagnosis.
Ribeiro-Dasilva et al. (2012)[46]	The PSQI global score for the TMD group was 6.4 (2.9), and 4.7 (2.0) for the control group. Interventions that target sleep quality improvement may also affect pain sensitivity in TMD patients.
Sanders et al. (2013)[10]	This article is one of the analyses generated from the OPPERA Cohort Study. The baseline case-control OPPERA study evaluated 1716 patients from 2006 to 2008. The authors reported that the individuals who reported a fairly good sleep quality ($n = 925$) presented a 2.03 (1.30, 3.17) OR for TMD onset. Individuals who reported fairly bad and very bad subjective sleep quality presented a 4.46 (2.75, 7.24) OR for TMD onset. These findings suggest that poor sleep quality could be considered a risk factor for TMD development. Other analyses showed that high likelihood of OSA could be associated with greater incidence of TMD.
Schmitter et al. (2015)[34]	The study reported a PSQI total score of 7.52 (3.72) for the TMD myofascial pain group and 4.38 (3.04) for the control group ($p = .006$). Sleep disturbances were associated with TMD.
Selaimen et al. (2006)[9]	The SAQ global score for the TMD group was 26.1 (9.2) and 17.8 (8.42) for the control group ($p < .001$). Sleep disturbance and depression should be considered risk indicators for the onset and development of TMD.
Şener & Guler (2012)[42]	The study reported PSQI global scores for myofascial pain (MFP) patients, disk displacement (DD) patients and healthy controls. The MFP group scored 7.27 (3.80), the DD group scored 5.64 (3.53) and the control group scored 4.06 (2.50). There was statistical difference between the MFP and the control groups ($p = .001$). Psychological assessments should be considered when treating MFP patients.
Smith et al. (2009)[11]	The PSQI global score for the myofascial pain TMD patients was 6.4 (3.5) and the ESS score was 8.5 (4.6). There was no reported data for controls. High rates of primary insomnia and sleep apnoea were present within TMD patients, which leads to the importance of a polysomnographic evaluation of those individuals.
Sousa (2015)[27]	Thirty-six of the 50 TMD patients (72%) suffered from sleep disorders, while 27 of the 50 (54%) TMD-free patients reported sleep disturbance. Patients who suffered from sleep disorders were 2.19 times more likely to develop TMD when compared to good sleepers (OR = 2.19).
Su et al. (2016)[32]	The study compared TMD patients according to pain intensity and pain-related disability. Within the low pain intensity group ($n = 156$), 28 ESS scores reported being sleepy or very sleepy during daytime. For the high pain intensity group ($n = 164$), 32 patients felt sleepy or very sleepy during daytime. Within the no pain-related disability group ($n = 236$), 39 patients reported daytime sleepiness and for the moderate-severe pain-related disability group ($n = 84$), 21 individuals reported daytime sleepiness. No statistical relationship was found ($p > .05$).
Vazques-Delgado et al. (2004)[51]	The study evaluated TMD and chronic daily headache (CDH) patients. No symptom-free control group was reported. The TMD group was diagnosed as myofascial pain (MP) or intracapsular pain (IC). The PSQI global score for the MP group was 11.1 (4.5). The IC group scored 7.9 (4.4). The MP group was statistically different from both CDH and the IC group. The IC group differed only from the MP group. Sleep quality was statistically worse in myofascial pain patients.

(Continues)

TABLE 3 (Continued)

First Author (Year) [Reference]	Results/Conclusions
Yap et al. (2021)[33]	The study reported PSQI scores for Axis I G1 (myalgia), G2 (disk displacement), G3 (arthralgia), combined TMDs (all groups together) and a TMD-free control group. The PSQI global score for combined TMDs were 6.86 (3.73), myalgia 8.49 (4.48), disk displacement 6.22 (3.2) and arthralgia 7.56 (4.24). All groups presented statistically significant higher scores than the control group (5.0 (2.22)).
Yatani et al. (2002)[37]	The mean value for the PSQI global score was 9.89 (4.47). There were no statistically significant differences for the primary diagnosis of TMD between good and poor sleepers. Sleep disturbance, pain severity and psychologic distress were frequent comorbidities in TMD patients.

Abbreviations: DC/TMD, diagnostic criteria for temporomandibular disorders; ESS, Epworth Sleepiness Scale; F, female; G1, muscular disorders; G2, disk displacements; G3, arthralgias; M, male; nTMD, controls; PSQI, Pittsburgh Sleep Quality Index; RDC/TMD, research diagnostic criteria for temporomandibular disorders; SAQ, Sleep Assessment Questionnaire; TMD, temporomandibular disorder patients.

TABLE 4 Result of the quality evaluation (Newcastle-Ottawa Scale – NOS) of the articles included in the meta-analyses using a star system. *N* = 19

Study	Selection	Comparability	Outcome/Exposure	Total
Benoliel et al. 2017[36]	★★	★★	★★	6★
Daher et al. 2018[19]	★★★	★★	★★★	8★
Dias et al. 2015[20]	★★	★★	★★	6★
De Leeuw et al. 2005[48]	★★	★★	★★	6★
Drabovicz et al. 2012[21]	★★★★	★	★★	7★
Dubrovsky et al. 2017[28]	★★★	★★	★★	7★
Eisenlohr-Moul et al. 2015[45]	★★	★★	★★	6★
Fillingim et al. 2011[47]	★★★★	★★	★★	8★
Lei et al. 2016[30]	★★★★	★★	★★	8★
Lei et al. 2016[31]	★★★★	★★	★★	8★
Moana-Filho & Babiloni, 2019[29]	★★★★	★★	★★	8★
Park & Chung, 2016[40]	★★	★★	★★	6★
Peixoto, 2016[23]	★★	★★	★★	6★
Rener-Sitar et al. 2016[39]	★★	★	★★	5★
Ribeiro-Dasilva et al. 2011[46]	★★	★★	★★★	7★
Schmitter et al. 2015[34]	★★	★★	★★	6★
Sener & Guler, 2012[42]	★★	★★	★	5★
Sousa, 2015[27]	★★	★★	★★	6★
Yap et al. 2021[33]	★	★★	★★	5★

a positive correlation between both variables. A 2021 systematic review on the association of TMD and sleep disorders[53] retrieved 22 papers. In this study, the only studies that reported conflicting results (ie no association) were the ones that approached sleep bruxism as a sleep disorder in both TMD and non-TMD patients.

The present SRMA showed a positive association between sleep and TMD in all Axis I diagnostic groups, as well as in the overall TMD analyses (ie no axis or group division), both in continuous and categorical data. This relationship can be specifically observed when the diagnostic group presented moderate to high pain levels, (ie muscle disorders and arthralgia/osteoarthritis/osteoarthrosis), as compared to disk displacements. Only three out of the 36 included articles did not report a statistically significant relationship between TMD and poor sleep quality (Table 3).[20,32,45] Based on the results of this SRMA, TMD and poor subjective sleep quality appear to be positively related, which agrees with the literature reviewed.

The OPPERA (Orofacial Pain Prospective Evaluation and Risk Assessment) Cohort Study is one of the largest (n = 3623) multicentre longitudinal studies concerning TMD. In addition to sleep quality, the OPPERA authors also included sociodemographic data, general health status, clinical and orofacial aspects, psychological functioning, pain sensitivity, cardiac autonomic responses and genetic analysis as important risk indicators for TMD.[56,57]

The OPPERA Cohort Study has originated several different articles. One of them aimed to identify whether poor sleep quality led to painful TMD or vice-versa.[58] The authors evaluated the participants

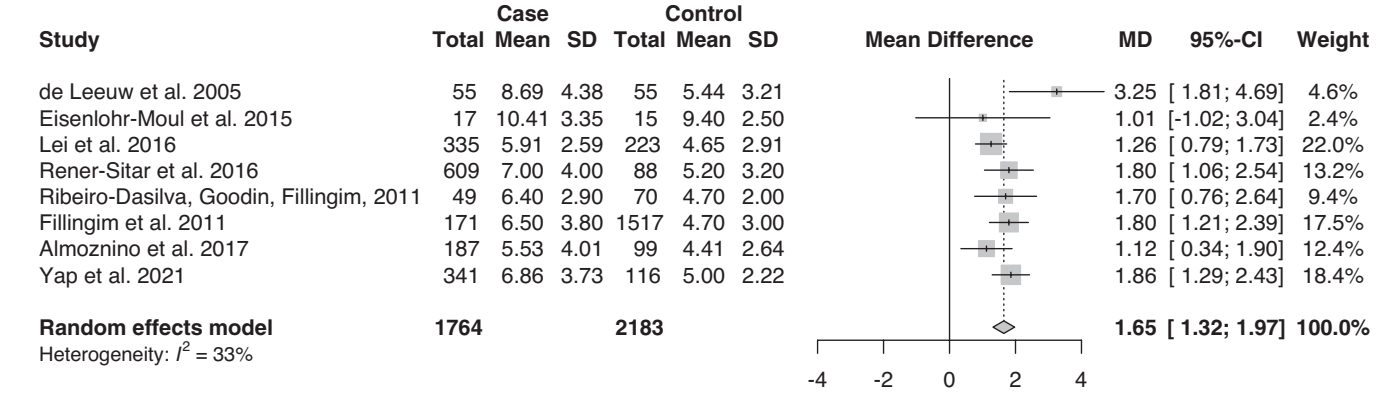

FIGURE 2 Forest plot of the sleep quality levels between the RDC/TMD or DC/TMD patients versus asymptomatic controls. Continuous data analysis (ie raw mean difference) for TMD global analysis (ie no axis or group division reported)

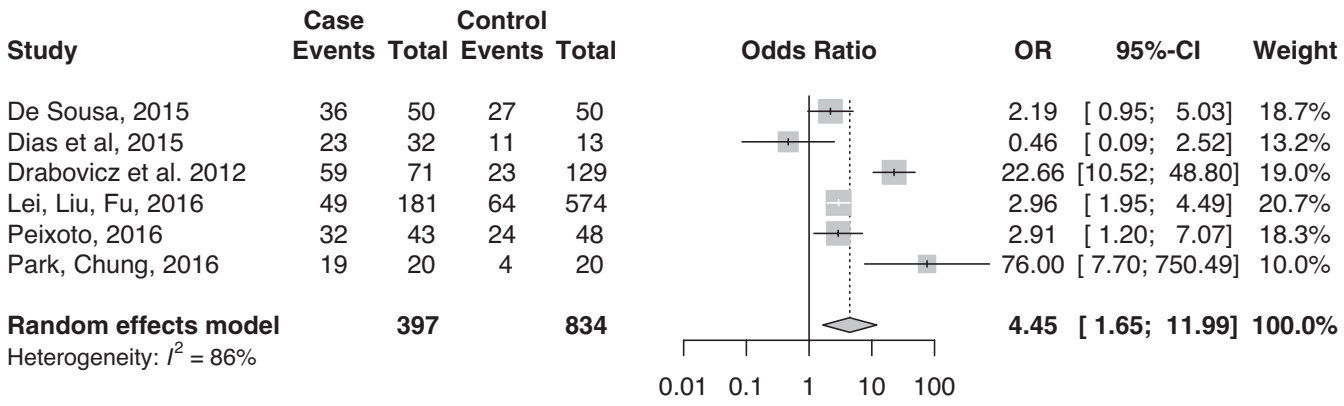

FIGURE 3 Forest plot of the sleep quality levels between the RDC/TMD or DC/TMD patients versus asymptomatic controls. Categorical data analysis (ie odds ratio) for TMD global analysis (ie no axis or group division reported)

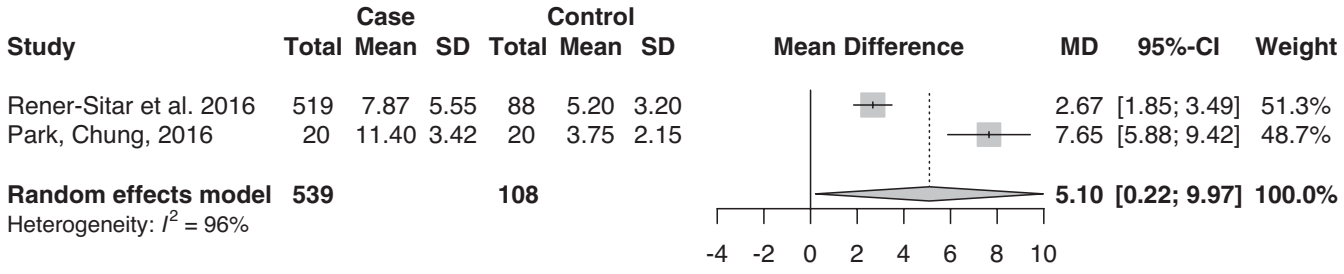

FIGURE 4 Forest plot of the sleep quality levels between the RDC/TMD or DC/TMD patients versus asymptomatic controls. Continuous data analysis (raw mean difference) for TMD AxisII analysis

for 2.8 years. It was observed that in initially TMD-free individuals, sleep quality usually deteriorated before the onset of painful TMD (ie 73% higher risk). The group that remained TMD-free presented no change in subjective sleep quality. Individuals who reported poor subjective sleep quality at baseline developed TMD at twice the rate as the good sleepers (HR = 2.04).

A case report has shown that patients with myofascial pain or arthralgia were particularly prone to suffer from insomnia and other sleep disorders, and that sleep quality improvement can be beneficial in the treatment of TMD.[59] Other studies have also reported that approximately 90% of TMD patients presented sleep disorders as comorbidities.[60] Coherently, disturbed sleep has been identified as a perpetuating factor for TMD when treatment does not work properly.[60] Insomnia is the most common sleep disorder in these patients, and an increase in the severity of insomnia can predict exacerbation of orofacial pain.[61] Another study regarding insomnia found that 37% of a 952 TMD sample suffered from moderate-to-severe insomnia and/or excessive daytime sleepiness.[62]

Other authors evaluated TMD and sleep quality by means of cross-sectional surveys assessing the general population,[63] the

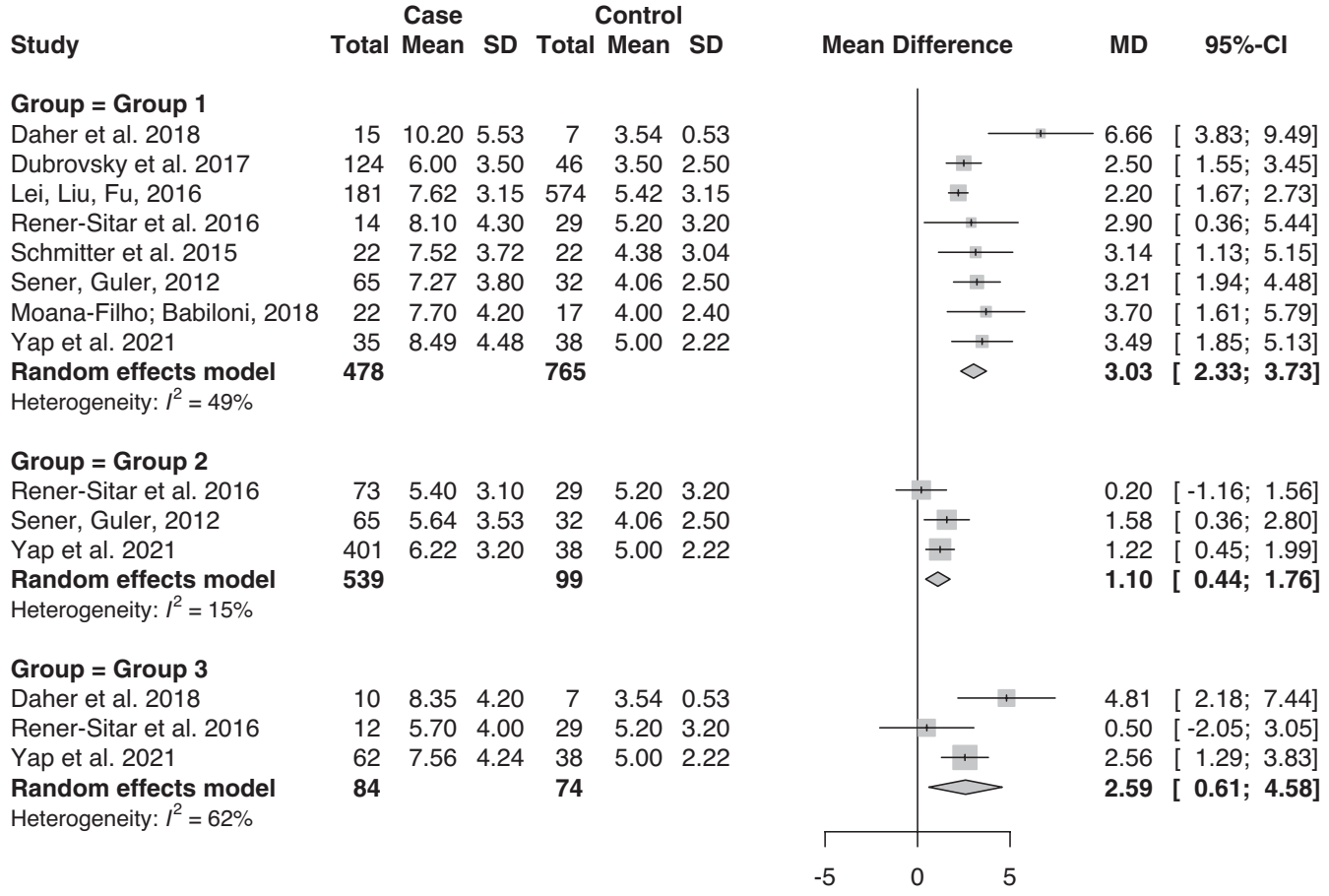

FIGURE 5 Forest plot of the raw mean difference of sleep quality levels between the RDC/TMD or DC/TMD Axis I only diagnostic groups versus controls. (a): Group 1 = muscle disorders; (b): Group 2 = disk displacements; and (c): Group 3 = arthralgia/osteoarthritis/osteoarthrosis

industry workers[64] and the nursing professionals.[65] They were not included in this SRMA, because they have used the Fonseca Questionnaire as a diagnostic method for TMD; however, all three articles found a statistically significant positive relationship between disturbed sleep and TMD.

Research on the mechanisms of the interaction between sleep quality and pain is still limited. During normal sleep, healthy adults usually present lower pain perception due to the reduction of nociceptive transmission. The activity of many neurons in the rostral trigeminal brainstem sensory nuclear complex (VBSNC) and their responses elicited by orofacial stimuli including noxious stimuli from the dental pulp are attenuated during REM sleep. This modulation happens because of glycine and gamma-aminobutyric acid (GABA) processes,[65] which contribute to the decreased responsiveness to external stimuli during NREM sleep and to the preservation of sleep continuity.

In acute pain, a positive and reversible relationship with sleep quality can be observed. Acute pain usually precedes sleep deterioration, and pain treatment improves sleep quality.[65] On the other hand, chronic pain seems to affect sleep quality in a loop. The worse the sleep quality, the worse the pain perception, and vice-versa.[66] Sleep quality can also be altered by a series of chronic pain states, leading chronic pain patients to become short sleepers (<6 h a day) or long sleepers (>9 h a day).[65]

Regarding the interaction of TMD and sleep, a population-based case-control study in 1643 subjects has shown that overall TMD subjects had significantly worse sleep quality than controls in the RDC/TMD Axis II Graded Chronic Pain Severity (GCPS) classification.[25] Sleep disorders were particularly worse in the Axis I TMD groups 1 and 3 (ie myofascial pain and arthralgia/osteoarthritis/osteoarthrosis) than in group 2 (ie disk displacements).[25] The results demonstrated that TMD pain level, and not TMD *per se*, is involved in worsening sleep quality. Coherently, in support of the biopsychosocial model of pain, worse results for quality of life, depression and somatization levels were also found for RDC/TMD Axis I groups 1 and 3 classification, which presented with higher pain levels, as compared to group 2.[3,67,68]

Regarding the neurophysiological mechanisms involved in the interaction between TMD and sleep quality, a review on the chronicity of TMD has shown that primary insomnia might share a common substrate underlying central sensitivity or play a causal role in the development of hyperalgesia in TMD patients. Researchers have

distinguished between TMD as a regional or widespread pain syndrome based on the identification of a "sensitive" TMD subgroup that had symptoms resembling fibromyalgia, which differed from an "insensitive" TMD subgroup. Decreased function in pain inhibitory systems and enhancement of pain facilitatory pathways have been included as mechanisms contributing to pain amplification. In response to emergent biological processes or environmental exposures, pain amplification may be due to both an inherited trait and a phenotype developed over time.[69]

The presence of subjective nonrestorative sleep is a powerful predictor of musculoskeletal pain.[66] In addition, sleep disorders, lack of sleep, sleep disruption and insomnia may reduce pain thresholds and may increase the chronic pain sensitivity.[59] Yet, the main question is as follows: which is the primary factor: low quality sleep or chronic pain presence? This question can be identified as a major limitation of this study, considering that most studies included were cross-sectional (Tables 2 and 3).

Other limitations for this study's interpretation can be also highlighted. Regarding TMD diagnosis, it can be stated that many articles reported neither the RDC or DC/TMD diagnostic groups for Axis I, nor the Chronic Pain Grade Classification for Axis II.[20–23,27,30–32,35,45,46,48,57] The RDC/TMD is validated for individuals who are 18 years and older, and our study evaluated individuals 16 years of age or higher, in order to being able to include relevant data from some large-sampled studies (eg Lei et al. 2016). Also, it is known that polysomnography is the gold standard tool for sleep quality diagnosis, which was not included in the eligibility criteria in this review.

The PSQI, SAQ and the ESS have been selected for being valid sleep screening tools. As the PSQI is the most widely used subjective sleep quality assessment tool, and for the objective of reducing heterogeneity, it was the only questionnaire considered for meta-analyses. Subjective sleep quality was considered as a whole (ie PSQI global score). Even so, high heterogeneity levels were found in two out of six forest plots. It has been shown that a PSQI global score higher than 5.0 is suggestive of both poor sleep quality and the possible existence of sleep disorders.[39]

Scientific research addressing the identification of each factor involved in the TMD multifactorial aetiology is necessary, given the increased prevalence and incidence rates of TMD, and the possibility of a better patient understanding. The main goal of TMD management is to provide a more comprehensive and personalised approach for each individual patient, with the purpose of improving quality of life outcomes.

As poor sleep quality is subject to intervention,[58] the present study suggests that a sleep assessment should be considered when treating TMD, as well as TMD should be considered as a possible comorbidity for individuals with low sleep quality. Systematic reviews and meta-analyses are on top of the scientific evidence pyramid, which points out the importance of this study in the TMD biopsychosocial model and multidisciplinary management, despite the heterogeneity and design limitations of observational studies included in this review.[70]

5 | CONCLUSION

A positive relationship between TMD and poor subjective sleep quality was observed. This association was found to be statistically significant in all RDC or DC/TMD Axis I diagnostic groups. The positive association was higher for groups 1 (ie muscle disorders) and 3 (ie arthralgia/osteoarthritis/osteoarthrosis), probably due to the lower pain levels reported for group 2 (ie disk displacements). Both TMD and poor sleep quality were also associated in both the global TMD (ie no axis or group division reported) and in the Axis II analyses. A 4.45 times increased odds ratio of TMD prevalence was found for individuals who presented worse subjective sleep quality in the categorical analysis measured by the PSQI.

Future research should provide control data and specify all RDC or DC/TMD axes and groups assessed. Polysomnographic studies should be a priority in order to properly access sleep disorders and sleep quality objectively.

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CONFLICT OF INTERESTS

None declared.

AUTHOR CONTRIBUTIONS

C. C. Roithmann and M. L. Grossi elaborated the study protocol, defined the PICO question and the eligibility criteria. C. C. Roithmann and C. A. G. da Silva were the main reviewers and performed data extraction. M. L. Grossi was the third reviewer. M. P. Pattussi performed quantitative data analysis and collaborated on the manuscript's revision. C. C. Roithmann, C. A. G. da Silva and M. L. Grossi performed manuscript writing, revising and submission. All authors approved the final version of the manuscript.

PEER REVIEW

The peer review history for this article is available at https://publons.com/publon/10.1111/joor.13265.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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