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REVIEW ARTICLE

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SLEEP DISORDERS AND MUSCULOSKELETICAL PAIN IN ADOLESCENTES: A SYSTEMATIC REVIEW

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ABSTRACT

Objective: To analyze an association between sleep disorders and musculoskeletal pain in adolescents. **Data source:** This systematic review was conducted according to the information collected in the Pubmed, Scopus and Cochrane Library databases, following the PRISMA guidelines. We included articles involving a population of adolescents between 10 and 19 years old, addressing subjects of sleep and skeletal muscle disorders, published until September / 2019 in English. There were no restrictions in the period of publication. **Summary of the data:** Among the 13 articles included in this research, 10 were associated with sleep disorders intensity and frequency of musculoskeletal pain. Only 1 article found a co-occurrence between sleep and headache problems for less than once a week and 2 without any association. **Conclusion:** The studies analyzed showed an association between sleep disturbance and musculoskeletal pain. Moreover, the authors report that this may compromise some aspects of sleep quality, with a two-way street between the variables.

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INTRODUCTION

Sleep is not just a period of rest for the body, it is also a time when the brain is still active (DAHL; LEWIN, 2010). Some aspects are important in the stages of sleep to enable the restorative process. If disturbances occur during this period, an individual may, for example, wake up fatigued due to insufficient sleep (DAHL; LEWIN, 2010; LYRA *et al.*, 2017). Thus, sleep is an important and fundamental component for health (DAHL; LEWIN, 2010). During adolescence, sleep becomes even more important, as this period is surrounded by a process of biopsychosocial changes which have a great impact on adolescent life (LYRA *et al.*, 2017). The prevalence of sleep problems in adolescents has increased over the years, from 31.2% in 2003 to 41.9% in 2012 (SING; KENNEY, 2013).

These sleep disturbances influence sleep-wake homeostasis cycle, causing damage to the individual, such as excessive sleepiness, as well as affecting behavioral, emotional and cognitive functioning (HARRISON *et al.*, 2014). Musculoskeletal pain and its association with sleep, specifically sleep problems (quality and quantity), has been an area of interest in research, as studies show that these problems are common in people with pain (ANDREUCCI *et al.*, 2017). A study in Finland (AUVINEN *et al.*, 2010) found that tiredness, difficulty in falling asleep and waking up at night are risk factors for musculoskeletal pain. In addition, Paananen *et al.* (2010) observed that short sleep time is a factor associated with musculoskeletal pain. In turn, Metwolly *et al.* (2004) conducted a study with 10-14-year-old adolescents with musculoskeletal pain and found that tiredness and difficulty in falling asleep are predictive factors for recurrent pain.

A longitudinal study (PAANANEM *et al.*, 2010) with more than 1,000 adolescents identified that insufficient sleep at 16 years of age is a risk factor for developing cervical and lower back pain at the age of 18. Some consequences of musculoskeletal pain are psychological distress, limitation of activities and limitations in social participation. In addition, individuals with musculoskeletal pain in adolescence are more likely to experience pain in adulthood (ANDREUCCI *et al.*, 2017). With this in mind, this study aims to analyze the association of sleep disorders and musculoskeletal pain. Therefore, a systematic review was carried out as a research strategy, as this type of study seeks to identify the existing evidence in the literature related to this topic. This research will support the plan of action practices directed at adolescent health.

MATERIALS AND METHODS

Protocol and Registration: This systematic review was conducted according to the information collected in the Pubmed, Scopus and Cochrane Library databases, following the guidelines of PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (MOHER *et al.*, 2009).

Eligibility Criteria: The PICO guiding question of the research was as follows: "Are sleep disorders associated with musculoskeletal pain in adolescents?", Being P: adolescents; I: presence of sleep disorders; C: absence of sleep disorders; O: musculoskeletal pain. To refine the research, the inclusion criteria were articles involving the population of adolescents between 10 and 19 years old, according to the characterization of adolescence according to the World Health Organization (WHO), which addressed the theme sleep disorders and musculoskeletal pain, published until September / 2019 in English language. There were no restrictions in the period of publication. Excluded from this selection were articles that were repeated in the databases, literature and systematic review articles, clinical trials, guidelines, letters, editorials, theses and dissertations, studies of populations with diseases or specific conditions in which pain is reported but is a result of the underlying disease or condition (for example, pain from rheumatoid arthritis).

Search Strategy

The keywords used were:(((("sleep wake disorders"[MeSH Terms] OR ("sleep"[All Fields] AND "wake"[All Fields] AND "disorders"[All Fields]) OR "sleep wake disorders"[All Fields]) OR ("sleep wake disorders"[MeSH Terms] OR ("sleep"[All Fields] AND "wake"[All Fields] AND "disorders"[All Fields]) OR "sleep wake disorders"[All Fields] OR ("sleep"[All Fields] AND "wake"[All Fields] AND "disorder"[All Fields]) OR "sleep wake disorder"[All Fields]) OR ("sleep wake disorders"[MeSH Terms] OR ("sleep"[All Fields] AND "wake"[All Fields] AND "disorders"[All Fields]) OR "sleep wake disorders"[All Fields] OR ("sleep disorders"[All Fields]) OR ("sleep wake disorders"[MeSH Terms] OR ("sleep"[All Fields] AND "wake"[All Fields] AND "disorders"[All Fields]) OR "sleep wake disorders"[All Fields] OR ("sleep"[All Fields] AND "disorder"[All Fields]) OR "sleep disorder"[All Fields])) AND (("musculoskeletal pain"[MeSH Terms] OR ("musculoskeletal"[All Fields] AND "pain"[All Fields]) OR "musculoskeletal pain"[All Fields]) OR

("musculoskeletal pain"[MeSH Terms] OR ("musculoskeletal"[All Fields] AND "pain"[All Fields]) OR "musculoskeletal pain"[All Fields]) OR ("musculoskeletal"[All Fields] AND "pains"[All Fields]) OR "musculoskeletal pains"[All Fields])) AND (("adolescent"[MeSH Terms] OR "adolescent"[All Fields]) OR ("adolescent"[MeSH Terms] OR "adolescent"[All Fields] OR "adolescents"[All Fields]) OR ("adolescent"[MeSH Terms] OR "adolescent"[All Fields] OR "adolescence"[All Fields]) OR ("adolescent"[MeSH Terms] OR "adolescent"[All Fields] OR "teens"[All Fields]) OR ("adolescent"[MeSH Terms] OR "adolescent"[All Fields] OR "teen"[All Fields]) OR ("adolescent"[MeSH Terms] OR "adolescent"[All Fields] OR "teenagers"[All Fields]) OR ("adolescent"[MeSH Terms] OR "adolescent"[All Fields] OR "teenager"[All Fields]) OR ("adolescent"[MeSH Terms] OR "adolescent"[All Fields] OR "youth"[All Fields]) OR ("adolescent"[MeSH Terms] OR "adolescent"[All Fields] OR "youths"[All Fields])).

Study Selection: The selection was performed in two phases. In the first phase, two independent evaluators (J.F.O.L. B and M.C.A.L.) read the titles and abstracts of the studies identified in the databases searched. Studies that did not meet the inclusion criteria were discarded. In the second phase, the same researchers applied the eligibility criteria for the full text of the articles. During the searches, disagreements were resolved by a third reviewer (M.V.H.).

Data Collection Process: In the data collection process, one author (J.F.O.L.B) extracted data of interest from the articles and these data were verified by two other authors (M.C.A.L and M.V.H). The qualitative data collected were: Author / year, country, age group, sample, study design and results. An inter-examiner test (Kappa) was performed to evaluate the authors' agreement for the selection of studies, obtaining a value of (0.78). Faced with disagreements between the authors, a third reviewer was consulted.

RESULTS

Study Selection: A total of 255 studies were found in the databases searched. After excluding the duplicates (20), 235 studies were evaluated by reading titles and abstracts. Only 61 articles were selected for full-text evaluation. After applying the eligibility criteria, 48 articles were excluded for several reasons, thus, 13 articles were part of the data extraction and qualitative synthesis. The process of identification, inclusion and exclusion of studies is presented in Figure 1. Regarding the temporal distribution, most studies were conducted in 2017 (23.07%) and 2012 (23.07%), while the remaining were carried out in 2016 (15.38%), 2018 (7.69%), 2015 (7.69%), 2014 (7.69%), 2007 (7.69%) and 1999 (7.69%). Regarding the geographic distribution, 53.84% of the studies were carried out in the European continent, 38.46% in the American continent and 7.69% in the Asian continent. Regarding the study design, 61.53% were cross-sectional and 38.46% longitudinal. Table 1 provides a panoramic view of the studies on sleep disorders and musculoskeletal pain included in this systematic review, highlighting the authors / year, country of origin, age group, sample, study design and results.

DISCUSSION

By analyzing the selected studies, it is observed that a variety of instruments were used for the assessment of sleep disorders,

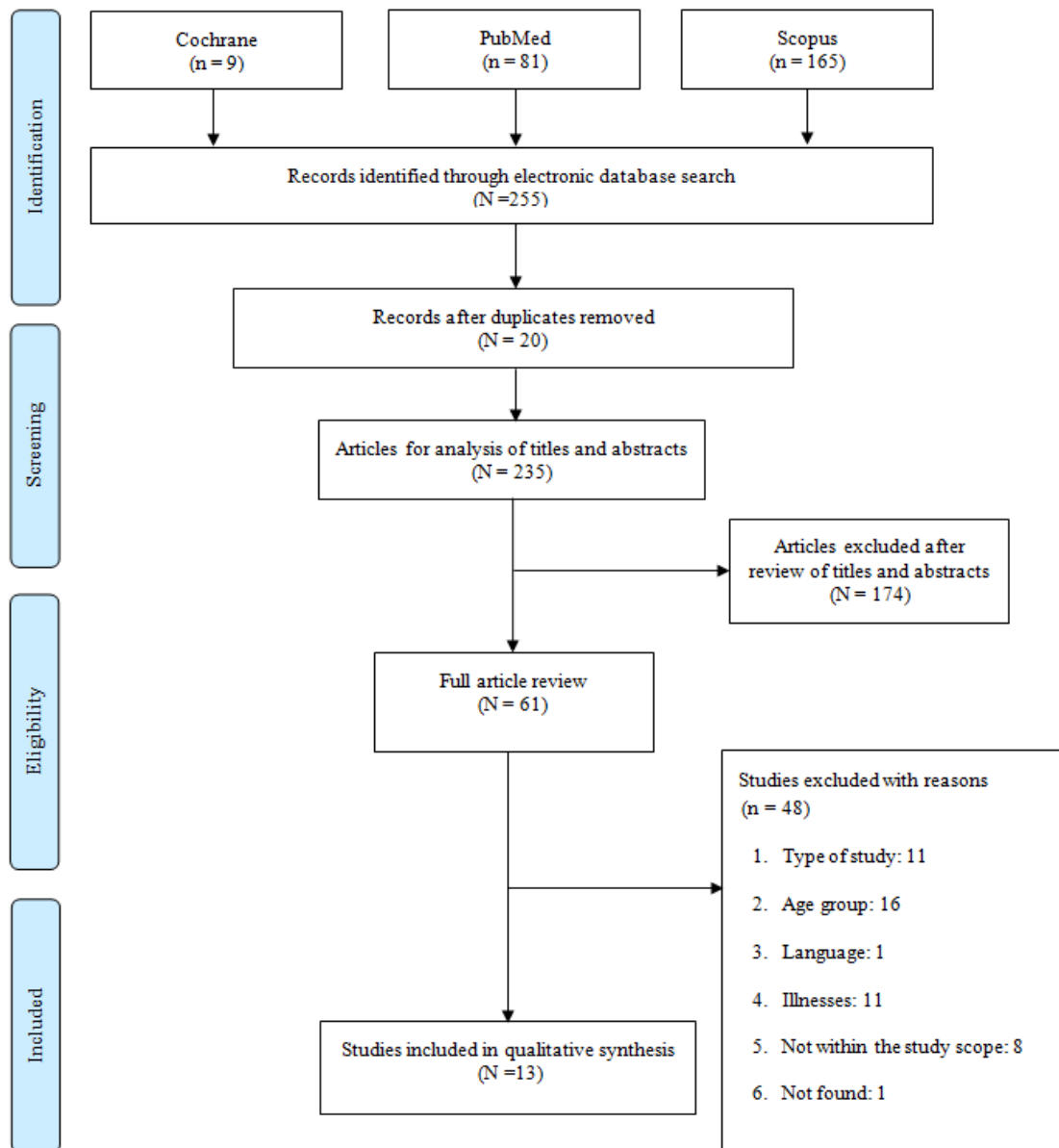


Figure 1. Study selection flow diagram according to the Prisma scale

Table 1. Presentation of articles by author, year, country, age group, sample, study design and results

AUTHOR / YEAR	COUNTRY	AGE	SAMPLE	STUDY DESIGN	RESULTS
1.Law <i>et al.</i> /2012	U.S.A.	15.07 (average)	121	Cross-sectional	Adolescents with chronic pain had higher intensity and frequency of pain, activity limitation, daytime sleepiness (p <0.001), longer nap duration (p <0.005), greater number of naps (p <0.003) compared to their healthy peers. In adolescents with chronic pain, activity limitation was related to the greater number of longer naps and naps (p <0.005).
2.Pavlova <i>et al.</i> /2017	Canada	8-18	147	Cross-sectional	Poor sleep quality was associated with higher pain levels (p <0.016) and pain interference with quality of life (p <0.001). Anxiety and depressive symptoms mediated the relationship between sleep quality and pain intensity and its interference in the individual's life.
3.Harrison <i>et al.</i> / 2014	United Kingdom	15 and17	2493	Longitudinal	Adolescents with sleep disorders (waking up 2-3x per night) were more likely to have regional chronic pain (OR 1.81 [95% CI 1.07 to 3.07]) and generalized chronic pain (OR 2.13 [95% CI 1.22 to 3.74]). Those who considered themselves poor sleepers were more likely to develop regional chronic pain (OR 1.61 [95% CI 1.01 to 2.58]) and generalized chronic pain (OR 1.77 [95% CI 1.07 to 2.91]). Hypersomnia was associated with regional chronic pain (OR 3.42 [95% CI 1.62 to 7.22]) and generalized chronic pain (OR 2.76 [95% CI 1.05 to 7.25]).

.....Continue

3. Watson, Brickson/ 2018	U.S.A.	Average age = 15.5 ± 1.6	65 (only girls)	Cross-sectional	Pain, fatigue, mood and stress improved with longer sleep duration (p = 0.042) and higher sleep quality (p <0.001).
4. Yabe et al./2017	Japan	6-15	6441	Cross-sectional	Awakening time (p <0.003), bedtime (after 9:30 pm, p <0.001) and sleep time (less than 9:30 am sleep per night, p <0.001) were associated with low back pain.
5. Palermo et al./ 2012	U.S.A.	12-18	61 with chronic pain and 60 healthy	Longitudinal	Symptoms of insomnia (p <0.001), activity limitation (p <0.001) and poorer quality of life (p <0.001) were more prevalent in adolescents with chronic pain compared to their healthy peers. Adolescents with chronic pain had higher symptoms of insomnia throughout the study (p <0.17) and at each follow-up phase (p <0.001). Adolescents with chronic pain had 1.5 times more symptoms of insomnia compared to their peers (P <0.001). Poor sleep hygiene was a predictor of insomnia (p <0.003).
6. de la Veja et al./ 2016	Spain	12-24	414	Cross-sectional	Sleep disorders were associated with higher pain intensity (p <0.001) and higher number of painful areas (p <0.01). Older adolescents reported worse sleep quality compared to younger ones (p <0.01), as well as reported higher pain intensity (p <0.05) and a greater number of pain sites (p <0.001).
7. Harrison et al./2016	United Kingdom	17	3568	Cross-sectional	Sleep disorders (prolonged sleep latency, difficulty in maintaining sleep, and excessive daytime sleepiness) were associated with a higher likelihood of head pain (OR = 2.37; 95% CI, 1.66-3.37; P <0.001) and abdominal pain (OR = 1.94; 95% CI, 1.43-2.63; P <0.001). Participants who reported sleep problems had a higher number of musculoskeletal pain symptoms compared with healthy ones (p <0.001).
8. Holley et al./ 2017	U.S.A.	10-17	88	Longitudinal	Chronic pain was not associated with sleep quality (P = 0.514).
9. Sundblad et al./ 2007	Sweden	9, 12 and 15	1908	Cross-sectional	No association between sleep and musculoskeletal pain was observed, although 13% of students reported sleep problems.
10. Luntamo et al./ 2012	Finland	13-18	2215	Cross-sectional	There was a co-occurrence between having sleep problems and headaches (OR: 1.4) and sleep problems with abdominal pain (OR: 1.1).
11. Bonvanie et al./ 2015	Holand	T4: 19.1 (average) T5: 22.3 (average)	T4: 1668 T5: 1416	Longitudinal	In the first assessment, sleep problems were associated with chronic pain (B 5 0.04, 95% CI [0.02-0.06]), musculoskeletal pain intensity (B 5 0.48, 95% CI [0.33-0.66]), severity of headache (B 5 0.52, 95% CI [0.35-0.69]) and abdominal pain (B 5 0.65, 95% CI [0.50-0.80]). After three years of follow-up, sleep problems significantly increased the likelihood of developing chronic pain (P <0.09).
12. Mikkelsen et al./ 1999	Finland	Generalized pain: 10.7 years (SD) 1.0 years Neck pain: 11.1 years (SD) 1.0 years No pain: 10.7 years (SD) 1.1 years	Generalized pain: 112 Neck pain: 93 No pain: 122	Longitudinal	Children with generalized pain had more sleep problems compared to those without any symptoms (p <0.0001).

such as Actigraphy (LAW et al., 2012), Adolescent Sleep-Wake Scale [ASWS] (PAVLOVA et al., 2017; YABE et al., 2017; PALERMO et al., 2012), Clinical Interview Schedules - Revised [CIS-R] (HARRISON et al., 2014; HARRISON et al., 2016;), Self-Reporting Questionnaires (WATSON; BRICKSON, 2018; YABE et al., 2017; HOLLEY et al., 2017; SUNDBLAD et al., 2007; LUNTAMO et al., 2012; MIKKELSSON et al., 1999), Sleep Hygiene Scale [ASHS] (PALERMO) et al., 2012), Pre-Sleep Arousal Scale [PSAS] (PALERMO et al., 2012), Pittsburgh Sleep Quality Index [PSQI] (de la VEJA et al., 2016), and Nottingham Health Profile [NHP] (BONVANIE et al., 2015). The same was observed for musculoskeletal pain, in which several instruments were used in the evaluation, such as the Numerical Rating Scale (LAW et al., 2012; PALERMO et al., 2012; YABE et al., 2017; de la VEJA et al., 2016; BONVANIE et al., 2015), Map of the human body (PAVLOVA et al., 2017; YABE et al., 2017; SUNDBLAD et al., 2007;), questionnaires assembled from other validated questionnaires (HARRISON et al., 2014; WATSON; BRICKSON, 2018; HOLLEY et al.,

2017; LUNTAMO et al., 2012; MIKKELSSON et al., 1999) and Chronic Pain Grade Questionnaire [CPGQ] (HARRISON et al., 2016), which limited the comparison of the results. It is also important to highlight the wide variety of samples used, since some studies were performed with 65 adolescents (WATSON; BRICKSON, 2018) and others with more than 2,000 adolescents (HARRISON et al., 2014; YABE et al., 2017; HARRISON et al., 2016; LUNTAMO et al., 2012), which can be explained by the variety of research designs used.

Regarding sleep disorders, the authors found that they are associated with higher intensity (LAW et al., 2012; PAVLOVA et al., 2017; DE LA VEJA et al., 2016; BONVANIE et al., 2015) and frequency, as well as pain (LAW et al., 2012) and also to a greater number of painful areas in the body (DE LA VEJA et al., 2016; HARRISON et al., 2016). Only one study (YABE et al., 2017) found that awakening time, bedtime, and sleep time were specifically associated with low back pain. Two other studies (PAVLOVA

et al., 2017; YABE *et al.*, 2017) found that poor sleep quality is associated with poorer quality of life, while one study (WATSON; BRICKSON, 2018) found that pain, fatigue and stress improved with longer duration and better sleep quality. There was great divergence regarding the different types of sleep disorders evaluated, including excessive daytime sleepiness (LAW *et al.*, 2012;), insomnia (PALERMO *et al.*, 2012), number of naps (LAW *et al.*, 2012;), sleep latency (LAW *et al.*, 2012), sleep efficiency (LAW *et al.*, 2012;), poor sleep quality (PAVLOVA *et al.*, 2017; HARRISON *et al.*, 2014, de la VEJA *et al.*, 2016; HARRISON *et al.*, 2016; HOLLEY *et al.*, 2017; SUNDBLAD *et al.*, 2007, LUNTAMO *et al.*, 2012; BONVANIE *et al.*, 2015; MIKKELSSON *et al.*, 1999), hyper somnolence (HARRISON *et al.*, 2014), and amount of sleep (WATSON; BRICKSON, 2018; YABE *et al.*, 2017). The same was observed in relation to musculoskeletal pain, in which chronic pain was evaluated (LAW *et al.*, 2012; PAVLOVA *et al.*, 2017; WATSON; BRICKSON, 2018; PALERMO *et al.*, 2012; de la VEJA *et al.*, 2016; SUNDBLAD *et al.*, 2007; BONVANIE *et al.*, 2015), regional pain (HARRISON *et al.*, 2014), generalized pain (HARRISON *et al.*, 2014; HOLLEY *et al.*, 2017; MIKKELSSON *et al.*, 1999), low back pain (YABE *et al.*, 2017), headache (HARRISON *et al.*, 2016; LUNTAMO *et al.*, 2012; MIKKELSSON *et al.*, 1999), abdominal pain (LUNTAMO *et al.*, 2012). Although the authors researched the association between sleep disorders and musculoskeletal pain, the different approaches used can limit the comparison of the data.

Among the studies that verified the prevalence of musculoskeletal pain (HARRISON *et al.*, 2014; YABE *et al.*, 2017; SUNDBLAND *et al.*, 2007), Harrison *et al.* found similar prevalence rates for regional chronic pain and generalized chronic pain, but when these pains occur simultaneously the prevalence decreased. Sundbland *et al.* (2007) found that more than half of the adolescents reported painful symptoms and Yabe *et al.* (2017) found that the prevalence of low back pain was no more than 5% in adolescents. Yabe *et al.* (2017) probably identified a lower prevalence as they evaluated pain in a single body site, i.e. the lower back, limiting the sample to the number of people who suffered from pain only in this part of the body. Adolescents with musculoskeletal pain had greater excessive daytime sleepiness (LAW *et al.*, 2012; HARRISON *et al.*, 2016), longer duration of naps (LAW *et al.*, 2012), greater number of naps (LAW *et al.* 2012), poor sleep quality (PAVLOVA *et al.*, 2017, HARRISON *et al.*, 2014), woke up 2-3x a night (HARRISON *et al.*, 2014), hypersomnolence (HARRISON *et al.*, 2014), insomnia (PALERMO *et al.*, 2012), prolonged sleep latency, difficulty in maintaining sleep (HARRISON *et al.*, 2016; MIKKELSSON *et al.*, 1999). However, it is important to highlight that some researchers presented a cross-sectional design (LAW *et al.*, 2012; PAVLOVA *et al.*, 2017; HARRISON *et al.*, 2016), thus, it is not possible to infer any causality.

Nevertheless, the longitudinal study carried out by Harrison *et al.* (2014) corroborates the above findings, since adolescents who had sleep problems at 15 years presented musculoskeletal pain at 17 years. In this study, adolescents who perceived themselves as "bad" sleepers had higher levels of musculoskeletal pain. Due to its longitudinal design, covering a population of adolescents, it is possible to compare the results of this research with those previously mentioned, as well as endorse the association between sleep disorder and

musculoskeletal pain, ratifying the causal relationship between the two variables. Chronic pain was associated with activity limitation by adolescents (LAW *et al.*, 2012; YABE *et al.*, 2017), with poorer sleep quality having higher pain intensity and higher number of pain sites in older adolescents (DE LA VEJA). *et al.*, 2016). This can be explained by phase delay, which is a biological change linked to the stages of puberty. This change associated with external factors, such as longer use of electronic devices, school hours that force them to wake up early and waking up later on weekends as a way of compensating their sleep deficit, is reflected in the consequent decrease in sleep quality and increase excessive daytime sleepiness (del CIAMPO, 2012; OWENS *et al.*, 2010; YIING *et al.*, 2010, FALLONE *et al.*, 2002).

Two studies found no association between sleep quality and musculoskeletal pain (HOLLEY *et al.*, 2017; SUNDBLAND *et al.*, 2007). In one of them, the main focus was the transition from acute musculoskeletal pain to chronic pain in adolescents seeking treatment and how biopsychosocial factors (sleep quality) could influence or predict pain-related persistence and functionality. The authors explain that the sample size was small, requiring a larger cohort and also longer follow-up to assess long-term effects (HOLLEY *et al.*, 2017). In another study, Sundbland *et al.* (2007) propose to evaluate the prevalence of self-reported pain and perceived health that included several factors, including sleep quality. The authors make no association between these factors, although they report that adolescents who had headaches were more likely to report frequent sleep problems than their peers who did not have these types of pain. The authors state that tiredness and lack of sleep can cause headaches, that is, the pain can be a factor in having trouble sleeping. However, as it is a cross-sectional study, it is also not possible to verify any casualty. Lutano *et al.* (2012) found no association between the variables, but observed co-occurrence between sleep problems and headache, as well as sleep problems and abdominal pain at least once a week. In turn, Bonvanie *et al.* (2015) found that sleep problems were associated with the severity of musculoskeletal pain and the severity of abdominal pain. These studies demonstrate a two-way street between the variables.

Limitations: Some methodological limitations are present in the studies included. Some used adolescents who sought medical attention in a pediatric hospital (PAVLOVA *et al.*, 2017), specialized clinics (PALERMO *et al.*, 2012; HOLLEY *et al.*, 2017), athlete-specific population (WATSON; BRICKSON, 2018; YABE *et al.*, 2017), and others. Despite the use of the same questionnaires, some specific question or parts of the questionnaires were used.

Conclusions

The studies analyzed demonstrate an association between sleep disorders and the presence of musculoskeletal pain. Moreover, they state that this pain may compromise some aspects of sleep quality and that there is a two-way street between the variables. Adolescents who had sleep problems had higher intensity and frequency of musculoskeletal pain.

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