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REVIEW

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Short sleep duration is associated with higher risk of central obesity in adults: A systematic review and meta-analysis of prospective cohort studies

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Abstract

Background and Objective: The relationship between sleep duration and obesity has been the focus of numerous investigations. This systematic review and meta-analysis of prospective cohort studies aimed to assess the relationship between sleep duration, abdominal obesity, and body composition.

Methods: PubMed, Scopus, and Web of Science were searched until February 2024. Cohort studies that assessed the relationship between sleep duration at night and central obesity measures or body composition indices in adults were included. The quality of studies was assessed using the Newcastle-Ottawa scale. Random-effects meta-analysis was conducted on studies that reported risk ratio (RR) and 95% confidence intervals (CIs).

Results: Eighteen studies were eligible to be included. Eleven out of the 18 studies were not included in the analysis as 10 studies did not report RR, and in one study, the definition of short and normal sleep duration was different from others. The results of the meta-analysis indicated that short sleep duration was significantly associated with abdominal obesity (RR = 1.08; 95% CI: 1.04–1.12; I^2 = 49.1%, n = 7), but long sleep duration was not (RR = 1.02; 95% CI: 0.83–1.24; I^2 = 98.2%, n = 6).

Conclusions: Short sleep duration was associated with a slightly higher risk of central obesity, while long sleep duration was not.

KEYWORDS

abdominal obesity, body composition, body fat, sleep duration, waist circumference

1 | INTRODUCTION

Sleep is critical for a person's health.[1,2] Adequate sleep is required for cognitive functioning, mental well-being, balanced mood, and cardiovascular and metabolic health. The National Sleep Foundation guidelines recommend 7–9 h of sleep per night for adults aged 18–64 years and state that 6 h or less and 10 h or more may have a negative impact on health and well-being.[3] However, it is estimated that nearly one in four people around the world have insomnia,[4] and as a broader term, poor sleep quality was shown in about one-third of the population of low and middle-income countries.[5] Higher-income countries are no exceptions where low sleep duration is prevalent.[6]

In fact, night shift work, high screen time, and anxiety are among the contributing factors to sleep disorders in the modern society.[7–9] Sleep deprivation can cause negative effects on physical and mental health and on personal and public safety.[1]

Observational studies have shown that low sleep duration is related to weight gain, reduced weight loss, and obesity.[10,11] A recent systematic review and meta-analysis indicated an inverse relationship between sleep duration and general obesity although heterogeneity was high.[12] However, obesity is a condition characterized by excess body fat, which is not only addressed by BMI but also by body composition analysis and waist measurement.[13] Moreover, high waist circumference (WC) and high fat mass have been observed to be related to chronic conditions such as type 2 diabetes, hypertension, and other cardio-metabolic complications.[14] Hence, not only general obesity but also abdominal adiposity and body fat mass deserve more investigation. Similar to general obesity, multiple observational studies have assessed the links between insufficient sleep as the predictor and central obesity or excess body fat as the outcomes.[15–19] Nonetheless, results of these studies are inconsistent, which warrants a systematic review to better comprehend the overall evidence.

Though not fully recognized and despite conflicting evidence, some proposed mechanisms underlie the relationship between low sleep duration and higher body fatness.[20] Endogenous alterations in appetite hormones or energy metabolism may play a role. Short sleep duration is associated with higher ghrelin levels,[21] thus contributing to higher food intake, weight gain, and higher fat mass.[22] In addition, leptin, a hunger inhibitor, is shown to be lower as a consequence of sleep restriction and deprivation.[23] Therefore, this state may lead to more hunger, especially toward appetizing calorie-rich foods. As another consequence of alterations in the levels of these regulators, a decreased metabolic rate may follow. These changes are hypothesized to be a kind of metabolic and endocrine overcompensation aiming at increasing energy intake and preservation to curb the excess energy needs associated with extended wakeful time. Additionally, dysregulation of adipose tissue homeostasis due to lower adiponectin levels is another avenue of this association.[24,25] Short sleep duration may also be associated with hyper-activation of the hypothalamic–pituitary–adrenal (HPA) axis, which increases the cortisol levels,[26] contributing to augmented body fat. Furthermore, changes in eating patterns toward excess calorie intake because of prolonged wakefulness or previously mentioned hormones, especially in obesogenic environments, have been stated in previous studies.[26,27] On the other side of the spectrum, too long sleep duration is assumed to reduce the metabolic rate and 24-h total energy expenditure, favoring weight gain.[27] These findings suggest a U-shaped relationship between sleep duration and obesity.[28]

Although several systematic reviews and meta-analyses have investigated the relationship between obesity and sleep duration, obesity is defined based on BMI in these studies. Only one meta-analysis has been performed on the association of WC with sleep duration.[29] This study was conducted in 2013 and included cross-sectional studies except one which had a cohort design. To the best of our knowledge, no study has systematically reviewed the prospective cohort studies, which are generally more robust than the cross-sectional studies, on sleep duration and abdominal obesity. It was hypothesized that there are relationships between sleep duration and risk of abdominal obesity in adults.

2 | MATERIALS AND METHODS

The protocol of this study has been registered in the International Prospective Register of Systematic Reviews (PROSPERO, CRD42022322890). PRISMA (preferred reporting items for systematic reviews and meta-analyses) statement was applied as guidance in reporting of this systematic review.[30]

2.1 | Literature search

The Participants, Exposures, Comparisons, Outcomes, and Study design (PECOS) framework was used to make search strategy. Participants of interest were adults aged ≥18. Exposure was short or long sleep duration at night. Normal sleep duration was considered as comparison. The cut-off points for sleep duration were not defined a priori; instead, what the studies defined as short, normal, and long sleep duration was considered. Cut-off values for short sleep duration varied from ≤5 to ≤7 h, normal duration was in the range of 6–8, and long sleep ranged from >8 to >9. The outcomes were body composition indices, including body fat percentage, fat mass, fat-free mass (FFM), abdominal obesity, visceral adipose tissue, WC, waist to hip ratio (WHR), and waist-height ratio (WHtR). Cut-off values for abdominal obesity differ by the ethnicity of the population, and various organizations have proposed different values. Thus, every otherwise eligible study that used one of the abdominal obesity measures suggested by WHO (WC, WHR, or WHtR)[31] irrespective of the adopted cut-offs, was included. The study design was prospective cohort study. A systematic search was conducted on web databases of PubMed, Scopus and Web of Science to identify eligible studies from inception up to 20 February 2024. No limiting filters were applied for the search. The search terms that were used as keywords in the search strategy are listed in Supporting Information S2. The reference list of the included articles were also scanned for relevant studies. Three researchers scrutinized titles and abstracts and then full-texts in duplicate for relevant studies. The records that met the inclusion criteria, based on the provided PECOS, were included in the analysis. The studies that used an intervention were not included.[32–34]

2.2 | Data extraction

Three authors extracted data from eligible studies using a predefined data-extraction form (AKo, NS, and FN). One author (AKo) checked the extracted data to ensure that all data were extracted correctly. For each included study, the required features, including author, publication year, country, sample size, age (mean or range),

BMI or weight categories, exposure, method of exposure assessment, outcome(s), method of outcome assessment, and adjusted variables, were extracted.

2.3 | Quality assessment

The quality of studies was assessed by the Newcastle-Ottawa scale.[35] Three domains, consisting of "selection," "comparability," and "outcome," were investigated to rate each study. In the "selection," four items were examined: representativeness of the exposed cohort, selection of the non-exposed cohort, ascertainment of exposure, and demonstration of the lack of outcomes at the start of the study. The "comparability" domain assessed the control of confounders in the design or analysis of the study. Lastly, in the "outcome" domain, ascertainment of outcome(s), duration of follow-up, and adequacy of follow-up of cohorts were checked. The scoring of each study was as follows: A score of 3–4 in the "selection" domain, 1–2 in the "comparability" domain, and 2–3 in the "outcome" domain rated the quality of study as "good"; A score of two in the "selection" domain, 1–2 in the "comparability" domain, and 2–3 in the "outcome" domain meant a "fair" quality; if a score of 0–1 was recorded for the "selection" domain, or 0 for the "comparability" domain, or 0–1 for the "outcome" domain, the quality of the study was considered "poor".

2.4 | Statistical analyses

Meta-analyses were conducted on studies that reported relative risks and 95% confidence intervals (CIs). Risk ratios (RRs) and 95% CIs were used as the effect sizes. We considered hazard ratios (HRs) equivalent to RRs.[36] For studies that reported odds ratios, we converted them to

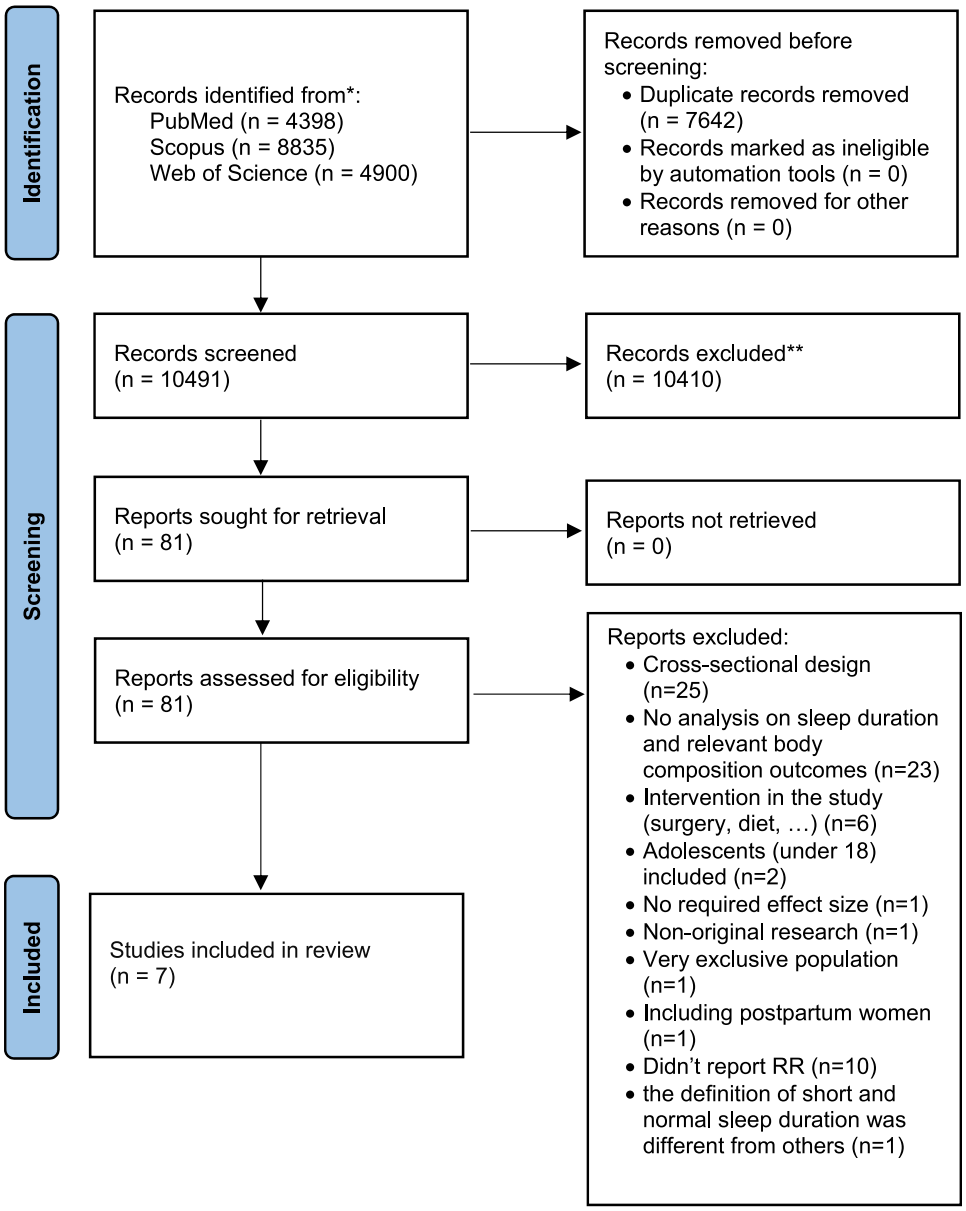

FIGURE 1 Flow diagram for the study selection process. RR, relative risk.

TABLE 1 Characteristics of cohort studies that assessed the relationship between sleep duration and markers of central obesity or body composition in general adult populations.

Study	Year	Country	Sample size	Number of cases (people sleeping less than recommended)	Participants characteristics	Age (mean), BMI (mean)	Follow-up duration	Assessment of sleep duration	Outcome, method of assessment
Peila, 2022[40]	(1993–1998) –2005	USA	5159	619 (<6 h) 1541 (6–<7)	Postmenopausal women (ages 50–79 years) free of metabolic syndrome or diabetes at enrollment in the Women's health initiative	62.3,[a] 27.93	9 years	Self-report	WC, tape by researchers
Yao, 2022[41]	2011–2015	China	5595	139 (≤5 h) 1347 (5–7 h)	Adults aged 45 years and above without abdominal obesity at baseline, from CHARLS (2011–2015), both sexes	Median: 58.8,[a] median: 21.1[a]	Median: 4 years, 33,486 person-years	Self-report	Abdominal obesity, WC ≥ 90 for men, WC ≥ 80 for women
Ning, 2020[15]	(2004–2008)–(2013–2014)	China	14,808	4559 (≤6 h)	Adults participating in China kadoorie biobank recruited from both urban and rural areas, both sexes	30–79, N/A	8.0 ± 0.8 years	Question	Central obesity, WC ≥ 90 in males, WC ≥ 80 in females
McMahon, 2018[19]	N/A	USA	390 (192M, 198F), 177 follow up	N/A	Healthy young adults with a BMI of 20–35 kg/m2, no major health conditions or large changes in body composition during the previous 6 months and no pregnancy or childbirth during the past 12 months, both sexes	27.6, 45% of participants with overweight/obesity and 55% normal BMI	2 years	Actigraphy	WHR, waist-to-height ratio, percent body fat
Deng, 2017[42]	1996–2014	Taiwan	162,121	30,092 (<6 h)	Adults from the MJ health database who were not obese and free from major diseases, both sexes	20–80, 22.7 ± 3.5	787,983 person-years	Self-administered questionnaire	Central obesity, tape by researchers
Kim, 2015[43]	(2005–2008)–(2008–2011)	Korea	2579 (913 M, 1666 F)	295 (<6 h)	Adults without metabolic syndrome from rural of wonju and pyengchang in South Korea, both sexes	54.5,[a] N/A	2.6 years	Self-report (face-to-face interview)	WC, tape by researchers
Theorell-Haglöw, 2014[44]	2000–2010	Sweden	4903	856 (<6 h)	Non-pregnant women, randomly selected from the population registry	43.9, 24.1	10 years	Questionnaire	WC, self-reported

Abbreviations: CT, computed tomography; CVD, cardiovascular diseases; DM, diabetes mellitus; PA, physical activity; T2DM, type-2 diabetes mellitus; VAT, visceral adipose tissue; WC, waist circumference; WHR, waist-to-hip ratio.

[a]Mean was calculated by authors based on the reported data in the article.

RRs according to the method of Zhang et al.[37] In primary studies, the relative risks of short and long sleep durations compared to the normal duration were combined using the DerSimonian and Laird's random-effects model.[38] Sensitivity analyses were conducted by excluding one study at a time and re-estimating the RRs to check whether a study with a large sample size or a study with an extreme result impacted the summary estimates. Moreover, sensitivity analysis was conducted by excluding studies that did not adjust for BMI since without this adjustment the importance of WC as a distinct adiposity measure is not fully recognized.[39] Stata version 16 software was used to conduct all statistical analyses.

3 | RESULTS

A total of 18,133 records were retrieved from the initial search; after removing the duplicates, 10,491 papers remained for screening according to title and abstract. Of these, 10,410 were found irrelevant or ineligible and were excluded. The remaining 81 full-texts were scrutinized, and 60 of them were excluded due to the following reasons: cross-sectional or other non-prospective designs, lack of analysis on sleep duration and relevant body composition outcomes, adolescents (under 18), lack of reporting of the required effect size, very exclusive population and study during and shortly after pregnancy. Ultimately, 21 papers from 18 studies (four papers were derived from one study) were eligible to be included based on the criteria. However, 10 studies did not report RR, and in one study, the definition of short and normal sleep duration was different (<8 h vs. ≥8). Therefore, seven studies were included in the meta-analysis.[15,19,40–44] Figure 1 illustrates the flowchart of the selection procedure. The list of studies that were not included in this systematic review and the respective reasons for exclusion are available in Supporting Information S2.

3.1 | Study characteristics and quality

The characteristics of the seven included studies are reported in Table 1. Six studies measured WC as the marker of central obesity, and one assessed the WHR. The participants in two studies were female,[40,44] and those in the remaining investigations were both males and females. Two studies were conducted in North America,[19,40] four in East Asia,[15,41–43] and one in Europe.[44] The sample size of the studies ranged from 390 to 162,121, and the duration of their follow-up ranged from 2 to 10 years. Two of the studies were not adjusted for BMI.[19,43] Five studies reported OR[15,19,40,43,44] and two HR.[41,42]

3.2 | Risk of bias assessment

Three of the studies were rated as having poor quality,[19,40,43] two as fair,[41,44] and two as having good quality,[15,42] according to the Newcastle–Ottawa scale. The results of the quality assessment are presented in Table 2. The main sources of bias were: (1) self-reported assessment of sleep duration in six studies; (2) general and central obesity (i.e., the outcome of the present review) which were already

TABLE 2 Quality assessment of the included studies that assessed the relationship between sleep duration and markers of central obesity or body composition in general adult populations.

Study	Representativeness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of exposure[a]	Demonstration that outcome of interest was not present at start of study[b]	Comparability	Assessment of outcome	Was follow-up long enough	Adequacy of follow-up of cohorts	Quality
Peila, 2022[40]	-	*	-	-	**	*	*	*	Poor
Yao, 2022[41]	*	*	-	*	**	*	*	-	Fair
Ning, 2020[15]	*	*	-	*	**	*	*	*	Good
McMahon, 2018[19]	*	*	*	-	-	*	*	-	Poor
Deng, 2017[42]	*	*	-	*	*	*	*	*	Good
Kim, 2015[43]	*	*	-	Unclear	-	*	*	*	Poor
Theorell-Haglöw, 2014[44]	-	*	-	*	**	-	*	*	Fair

[a]Studies that used objective method for exposure assessment was considered as low risk of bias.

[b]The studies that did not include participants with obesity, or BMI and waist circumference mean of participants at baseline were <25 and <85, respectively were considered at low risk of bias.

present at the beginning of the study in two studies and unclear in one study; only four studies reported that they excluded subjects with obesity at baseline; (3) two studies did not adjust for BMI, two did not adjust for depression, one did not adjust for alcohol intake, and one did not adjust for smoking ; and (4) participants of two studies were from a special group of population (young and post-menopausal women). Sources of bias are reported in Supporting Information Table S1.

3.3 | Meta-analysis

Seven cohort studies with 194,342 participants were included in the high versus low meta-analysis[15,19,40–44] for short sleep duration (defined as <6 h in six and <7 in one study) and six studies with 194,165 participants[15,40–44] for long sleep duration (>8–9 h). Short sleep duration compared with the normal duration indicated a significant increase in abdominal obesity (RR = 1.08; 95% CI: 1.04–1.12; I^2 = 49.1%, Figure 2). No association was observed between long sleep duration and abdominal obesity (RR = 1.02; 95% CI: 0.83–1.24; I^2 = 98.2%). Although the heterogeneity was high for long sleep duration, after excluding one study, I^2 reduced to 27.4% (RR = 1.03; 95% CI: 0.98–1.09). Moreover, the sequential removal of studies did not change the direction or magnitude of the pooled RR (RR range = 1.06–1.095 for short duration and 0.97–1.03 for long duration). A sensitivity analysis was performed after the exclusion of studies that did not adjust for BMI. The relationship between short sleep duration and abdominal obesity remained significant after excluding two studies that did not adjust for BMI (RR = 1.07; 95% CI: 1.03–1.12; I^2 = 59.8%); the relationship between long sleep duration and abdominal obesity also did not change after excluding the two studies (RR = 1.00; 95% CI: 0.81–1.25; I^2 = 98.4%).

4 | DISCUSSION

In this study, prospective cohorts that investigated the relationship between sleep duration and abdominal obesity or body composition indices in adults were systematically reviewed. Results of the meta-analysis showed that short sleep duration (mainly <6 h) compared to normal duration was associated with an 8% increase in the risk of abdominal obesity; such a relationship was not observed for long sleep duration (≥8 to >9 h).

Most of the studies included in the meta-analysis had fair/good quality and adjusted for important confounders. Although two studies did not adjust for BMI, which may cause bias because part of

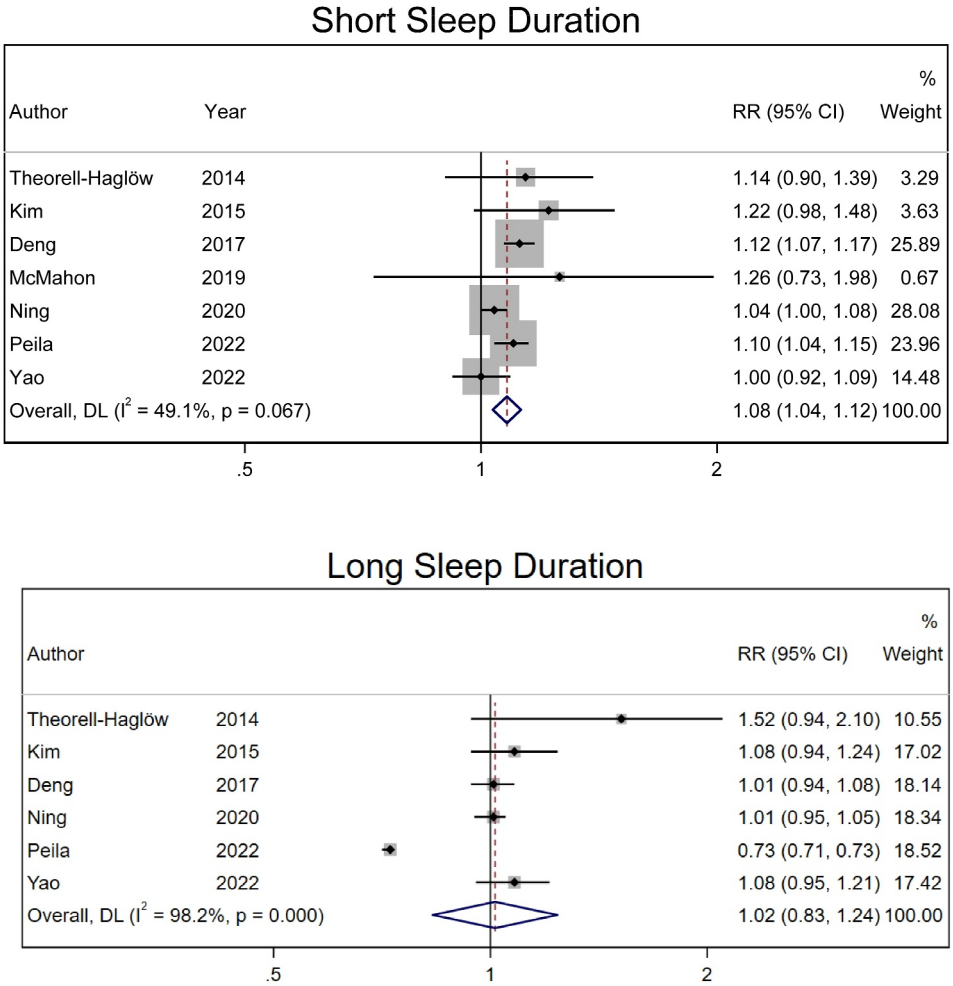

FIGURE 2 Summary risk ratio of abdominal obesity for the short and long compared with the normal sleep duration.

the relationship could be ascribed to general obesity rather than abdominal obesity, excluding these studies did not change the results.

To the best of our knowledge, the current systematic review is the first one that has assessed prospective cohort studies that evaluated the relationship between sleep duration and central obesity. A meta-analysis of 21 cross-sectional studies that examined sleep duration and WC indicated a significant negative relationship between sleep duration and WC.[29] Several meta-analyses have also verified the association of sleep with general obesity. The most updated one, which pooled 12 studies, revealed that a short sleep duration significantly increased the risk of obesity.[12] The findings of the present review could fill the gaps in the literature regarding central obesity and body adiposity.

The strength of this study is that all included studies are prospective cohorts, which can better detect causal relationships than cross-sectional studies. One limitation was that half of the studies had poor quality, so the future studies should be well-designed and address the limitations of current studies. The next limitation is the self-reported assessment of sleep duration and not an objective quantification in the included studies. Moreover, some of the studies did not adjust for BMI which may cause bias; however, most of these studies did not find a significant relationship. Lastly, in most of the studies, participants were overweight or obese at baseline which reduced the generalizability of the results to the normal-weight population. It is suggested that future studies should be conducted on normal weight participants with no central obesity at baseline.

5 | CONCLUSION

In conclusion, short sleep duration is associated with a slightly higher risk of central obesity, whereas no significant relationship was observed for long sleep duration.

AUTHOR CONTRIBUTIONS

Ali Kohanmoo, Masoumeh Akhlaghi and Asma Kazemi devised the concept and designed the research; Ali Kohanmoo conducted the search; Ali Kohanmoo, Najmeh Sasani and Fatemeh Nouripour performed the screening and data extraction; Ali Kohanmoo and Asma Kazemi wrote the article; Masoumeh Akhlaghi, Asma Kazemi and Caterina Lombardo substantially edited the manuscript. All authors have read and approved the final manuscript.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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