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EPIDEMIOLOGY • REVIEW

Experimental sleep restriction effect on adult body weight: a meta-analysis

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Abstract

Background Sleep is increasingly recognized as a potential risk for overweight and obesity. Observational studies have shown links between short sleep duration with weight gain. However, the findings from longitudinal studies in adults are conflicting. This review aimed to examine the effectiveness of experimental sleep restriction on adult body weight.

Method A systematic search was undertaken in MEDLINE, EMBASE, PsycINFO, and CENTRAL (Cochrane center register of controlled trials) to identify experimental studies examining the effectiveness of sleep restriction on body weight, and search period was from January 2005 to June 2018. Meta-analysis was applied by using the random model.

Results A total of 275 adults from six experimental studies were included. The pooled standard mean difference in body weight and body fat was 0.44 (95% CI −0.13 to 1.02) ($Z = 1.51$, $p > 0.05$) and 0.35 kg (95% CI −0.19 to 0.88) ($Z = 1.27$, $p > 0.05$), respectively. The experimental sleep restriction did not result in significant differences in adult body weight or body fat. Subgroup analysis showed that there were differences in weight gain between genders and races.

Conclusion The finding from this review cannot support the hypothesis from observational studies that short sleep leads to weight gain.

Keywords Sleep · Adult · Body weight · Meta-analysis

Introduction

Insufficient sleep is a significant public health problem due to the association with injury, chronic diseases, and mortality [1] and is also increasingly recognized as a potentially modifiable risk factor, which may contribute to the complex etiology of obesity [2]. In the past few years, observational studies have shown links between short sleep duration with weight gain [3–5]. Over the same time period, the rise of the obesity rate is paralleled with a reduction of sleep time [6]. A prospective cohort study of adults indicated short sleep duration resulted in more weight gain compared with the traditional risk factors, such as insufficient physical activity and high-energy diet [7]. Some studies also found that insufficient sleep may enhance hedonic stimulus processing in the brain and lead to overeating through underlying the drive to consume food [8]. Moreover, some factors associated with body weight change have been found to be associated with short sleep duration, including increased insulin and fasting glucose as well as decreased ghrelin, inflammation, and leptin [9–11].

The relationship between sleep and obesity in children has been consistently reported that declining sleep duration was associated with increasing weight gain [12, 13], while in adults, the findings from longitudinal studies [3, 14, 15] were conflicting. One study [14] that followed 68,183 females for 16 years found that those sleeping 5 h or less gained more weight about 1.14 kg (95% CI 0.49, 1.79) compared with those who slept for 7 h. Another large-scale prospective study [15], which followed up for 1 year, showed that males sleeping less than 5 h had higher odds ratios (OR = 1.91, 95% CI [1.36, 2.67]) for the development of obesity than those sleeping more, but no significant relationship between sleep duration and weight gain or obesity was found for females. A systematic review [3] conducted in 2014 included 11 prospective adult studies showed that shorter sleep duration was associated with increased risk of obesity both in males (OR = 1.65, 95% CI [1.24, 2.19]) and females (OR = 1.25, 95% CI [1.06, 1.47]).

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Many systematic reviews have explored the relationship between sleep duration and the prevalence of obesity in the cohort, cross-sectional [12, 13], or longitudinal [16–18] studies. Recently, a systematic review and meta-analysis [19] conducted in children showed that experimental studies involving a sleep component were not significantly effective in changing BMI ($n = 360$, -0.04 kg/m^2, 95% CI [-0.18, 0.11], $I^2 = 0\%$). However, no review has been conducted among adults to examine the effectiveness of experimental sleep restriction on body weight.

According to recent evidence about the association between sleep duration and overweight or obesity among adults, it is meaningful to conduct a synthesis of experimental studies targeting sleep restriction on body weight. This systematic review aimed to examine the impact of experimental sleep restriction on adult body weight and also tried to offer more evident to solve conflicting finding of observational studies.

Methods

Based on the study protocol and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [20], the meta-analysis was conducted. The study protocol is available if you email the corresponding author.

Eligible criteria

Type of participants

The age of the participants was 18 years or more. They were not diagnosed with sleep apnea or sleep disorders and also did not use any surgical and pharmacological strategies, which may impact sleep or body weight.

Types of interventions

All experimental studies examining the effectiveness of sleep restriction on body weight were included. Interventions of which sleep restriction was an explicit component were also included. But the trials that experimental length was less than 24 h were excluded.

Type of outcome measures

The primary outcome was the mean body weight change between pre-intervention and post-intervention. The secondary outcome of efficacy was the change in body fat, and the summary measure was the standard mean difference.

Types of studies

Randomized controlled trials published from January 2005 to June 2018 in English were included in the review. Observational studies, reviews, and protocols were excluded.

Data sources and search strategy

According to the study protocol, four electronic databases (MEDLINE, EMBASE, PsycINFO, and CINAHL [Cochrane Center Register of Controlled Trials]) were searched by Haiqing Yu (HQY) and Jiao Lu (JL) to identify the available articles, and the search period was from January 2005 to June 2018. A robust search strategy was developed by using keywords and Mesh terms according to four facets of the research question: population-human (adult), intervention, sleep, and outcome-weight. For text search, the combination of synonyms, truncation, wildcards, and spelling variation with symbol "adj," using Boolean operators "AND," "OR," and "NOT" to combine these terms (Appendix 1).

Study selection

All identified articles were imported to RefWorks software [21], where duplicated articles were deleted. Remaining articles' titles and abstracts were screened by HQY and Can Liu (CL) based on the criteria of eligibility. There was a disagreement about whether including the papers that had phase "body composition" as outcomes rather than body weight in abstracts. All reviewers met to discuss and established a consensus to include in case of missing any papers. Prior to screened full-text papers, the reviewer Jingmin Cheng (JMC) and Pengli Jia (PLJ) assessed independently a random sample of 10% papers to ensure all eligible studies were included. Prior to data extraction from included papers, all included articles were assessed by JMC and JL independently. The numbers of articles were presented in the flow diagram (Fig. 1).

Data collection process

A data extraction form (Appendix 2) was developed by HQY and then checked by JMC, JL, and PLJ for completeness. Data of included articles were then extracted by HQY and CL independently and rechecked by reviewer JMC and PLJ.

Risk of bias assessment

Methodological quality of the included studies was assessed by reviewer HQY and JMC independently

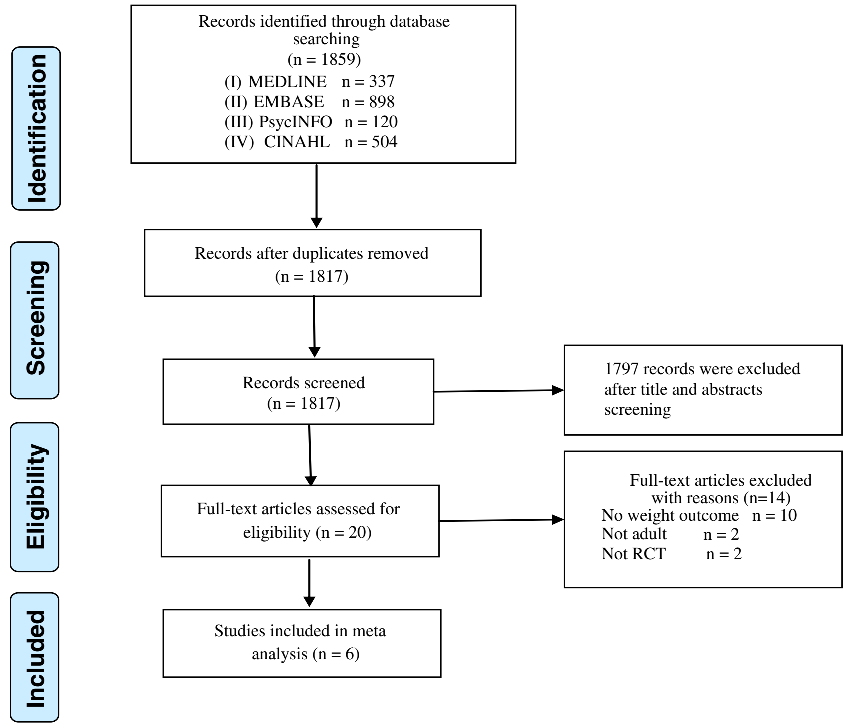

Fig. 1 Flow diagram of articles included

according to the Cochrane risk of bias tool for RCTs (randomized controlled trials) [22]. Sequence generation, allocation concealment, blinding of participants, personnel and outcome assessors, incomplete outcome data, selective outcome reporting, and other potential sources of bias were evaluated according to the tool. There was a disagreement about ranking the item "blinding outcome assessment"; all reviewers met and decided on evaluating as "low risk of bias" because the tools used to calculate body weight in these studies were objective and standard, although no blinding during outcome assessment.

Statistical analysis

Meta-analysis was applied in this review by using software Review Manager version 5.3 [23]. Mean change in body weight and body fat of included studies was analyzed. The heterogeneity between studies was tested using Cochran's Q. The I^2 was applied to examine and quantify the magnitude of heterogeneity between studies.

Where the studies were sufficiently homogeneous, the studies were pooled into a Hedges-*g* random effects model as previous review [19]. Where studies were unable to be pooled, narrative synthesis of results was performed. When standard deviations were missing, utilizing the standard error or confidence intervals to calculate. Publication bias was detected by using funnel plot and Egger's test, which was done through software "Comprehensive meta-analysis" (trial version) [24].

Subgroup analysis

Subgroup analysis was conducted for weight change and fat change comparing males and females and also African Americans versus Caucasians.

Sensitivity analysis

Sensitivity analysis was carried out by excluding trials that sleep restriction combined with caloric restriction and also considering age factor that its range was narrow.

Results

Study selection

Total 1817 records were left after removing duplicates. Among the remaining papers, 1797 studies were excluded. Of which, 1689 records were unrelated to both sleep and body weight or not interventions. Ninety-four studies were weight interventions rather than sleep interventions. Seven papers were sleep apnea-related interventions. Four studies were not RCTs. Three studies were sleep interventions, but no body weight was available as outcome.

Table 1 Study characteristics

Study	1. Type of the RCT 2. Experimental Length	Participants (adults)	Country	Numbers	Intervention description	Stated outcomes
Calvin 2014 [25]	1. Paralleled group RCT 2. Duration 8 days	38% females Mean age 25 years Mean BMI 22 kg/m^2	United States	Intervention $N = 8$ Control $N = 8$	Intervention-sleep 5.1 h/night Control sleep 6.9 h/night	Body weight, caloric intake, blood pressure
Nedeltcheva 2009 [28]	1. Crossover RCT 2. Duration 14 days	45% females Mean age 39 years Mean BMI 27 kg/m^2	United States	Intervention $N = 11$ Control $N = 11$	Intervention-sleep 5.5 h/night Control sleep 8.5 h/night	Body weight, energy intake, energy expenditure
Nedeltcheva 2010 [29]	1. Crossover RCT 2. Duration 14 days	30% females Mean age 41 years Mean BMI 27 kg/m^2	United States	Intervention $N = 10$ Control $N = 10$	Intervention-sleep 5.5 h/night + caloric restriction Control-sleep 8.5 h/night + caloric restriction	Body weight, hormone
O'Keeffe 2013 [30]	1. Crossover RCT 2. Duration 5 days	48% females Mean age 35 years Mean BMI 24 kg/m^2	United States	Intervention $N = 27$ Control $N = 27$	Intervention-sleep 4.0 h/night Control-sleep 9.0 h/night	Body weight, blood pressure, fasting lipid profiles
Spaeth 2013 [26]	1. Paralleled group RCT 2. Duration 5 days	45% females Mean age 31 years Mean BMI 24 kg/m^2	United States	Intervention $N = 198$ Control $N = 27$	Intervention-sleep 4.0 h/night Control-sleep 10.0 h/night	Body weight, caloric intake, food/drink timing
Wang 2018 [27]	1. Paralleled group RCT 2. Duration 8 weeks	81% females Mean age 45 years Mean BMI 34 kg/m^2	United States	Intervention $N = 21$ Control $N = 15$	Intervention-reducing sleep time 90 min for 5 days each week + caloric restriction Control-keeping normal sleep time + caloric restriction	Body weight, caloric intake, resting metabolic rate

Finally, 20 papers were eligible for full papers review; six studies were included, while others were excluded with different reasons (Fig. 1).

Description of studies

All trials were carried out among adults in the USA. Three studies [25–27] were paralleled group randomized controlled trials, and the remaining three studies [28–30] were crossover randomized controlled trials (Table 1). Of these trials, two studies combined sleep restriction and caloric restriction as the intervention [27, 29]. A total of 275 participants were included. Sample size ranged from 8 to 198 in sleep restriction group. The age ranged from 25 to 45 years old. All studies included both males and females; of which, the percentage of females in one study [27] was more than 80%, while the other five [25, 26, 28–30] studies were less than 50%. In three studies [25, 26, 30], trails were conducted in normal-weight (BMI < 25 kg/m^2) [1] subjects. The sleep restriction duration varied from 5 days to 8 weeks.

Risk of bias

Random sequence generation and blinding the participants and personnel were rated as having an unclear risk of bias in most trials [26–30], because they were not well reported. It was unclear whether having another risk of bias in the washout period for crossover RCTs [28–30]. The judgment about each risk of bias item was presented in Fig. 2. The detailed risk of bias for each study was given as an additional appendix (Fig. 3).

Synthesis of results

Body weight

The result of weight change was presented using a forest plot (Fig. 4). Six adult studies were included in the meta-analysis. Of these trials, two studies combined sleep restriction with caloric restriction [27, 29]. Meta-analysis of the six studies found that experimental sleep

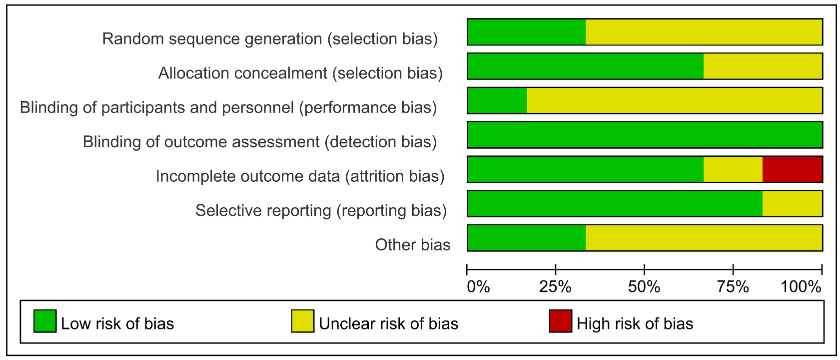

Fig. 2 Risk of bias graph: review authors' judgment about each risk of bias item presented as percentages across all included studies. The bars represent the proportions of studies with low, high, or unclear risk of bias in each respect of study design

restriction did not result in significantly more weight gain compared with the controlled group [0.44 kg (95% CI −0.13 to 1.02) ($Z = 1.51$, $p > 0.05$).

Body fat

The forest plot from the meta-analysis of body fat change was offered in Fig. 5. Three studies were included. Of which, sleep restriction was a part of the intervention with caloric restriction [27, 29]. The result from meta-analysis showed that experimental sleep restriction did not result in significantly more body fat [0.35 kg (95% CI −0.19 to 0.88) ($Z = 1.27$, $p > 0.05$).

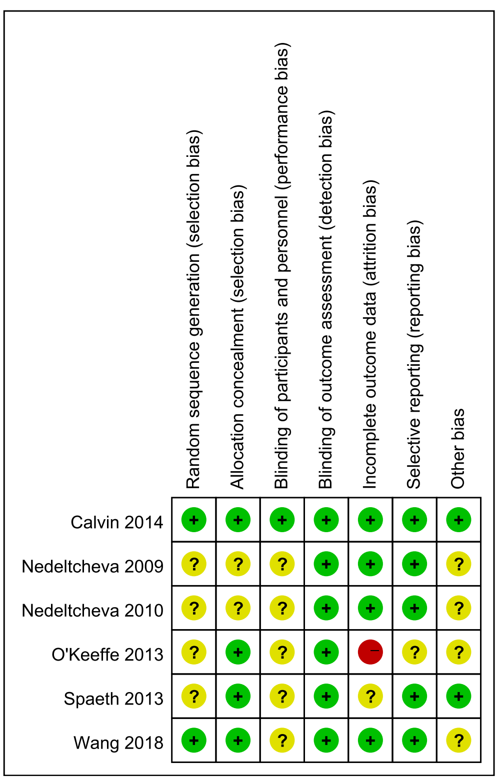

Fig. 3 Risk of bias summary: review authors' judgment about each risk of bias item for each included study. + indicates a low risk of bias; − indicates a high risk of bias; ? indicates unclear risk of bias in each respective aspect of study design

Subgroup analysis

Females versus males

Two studies reported the difference in weight change between genders [27, 29] and found that males gained more weight than females after sleep restriction ($p < 0.05$). One study [26] also reported males gained a larger percentage of body weight (1.6 ± 2.0%, $p = 0.02$) and increased a greater BMI (0.3 ± 0.50, $p = 0.03$) compared with females (1.11 ± 1.96%, 0.26 ± 0.47) among sleep-restricted subjects.

African Americans versus Caucasians

The difference in weight change by races was assessed in two studies [26, 27]. The finding in one study [26] was that more percentage of weight (1.7 ± 2.2%, $p = 0.002$) and BMI (0.4 ± 0.52, $p = 0.003$) were exhibited in African Americans than Caucasians (percentage of admittance weight change 0.94 ± 1.8%, 0.22 ± 0.42). The other one study [27] found that African Americans had significantly less weight when sleep restriction combined with caloric restriction.

Sensitivity analysis

Due to the largest difference in weight change was in experimental studies which sleep restriction combined caloric restriction, these trials are excluded. In order to minimize the influence of age, choosing the studies that the gap between ages was narrow. The result was presented in Fig. 6 and found that sleep restriction also did not result in significantly more weight gain [0.77 kg (95% CI −0.17 to 1.70) ($Z = 1.61$, $p > 0.05$).

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Calvin 2014	1.1	1.1	8	0.8	1.3	8	13.7%	0.24 [-0.75, 1.22]
Nedeltcheva 2009	1.9	1.6	11	2.1	2.1	11	15.4%	-0.10 [-0.94, 0.73]
Nedeltcheva 2010	-3	1	10	-2.9	1.4	10	14.9%	-0.08 [-0.96, 0.80]
O'Keeffe 2013	-0.77	0.18	27	-1.09	0.18	27	17.9%	1.75 [1.12, 2.39]
Spaeth 2013	0.97	1.4	198	0.11	1.9	27	20.5%	0.58 [0.18, 0.99]
Wang 2018	-3.2	2.5	21	-3.3	3.2	15	17.5%	0.03 [-0.63, 0.70]
Total (95% CI)			**275**			**98**	**100.0%**	**0.44 [-0.13, 1.02]**

Heterogeneity: Tau² = 0.38; Chi² = 20.85, df = 5 (P = 0.0009); I² = 76%
Test for overall effect: Z = 1.51 (P = 0.13)

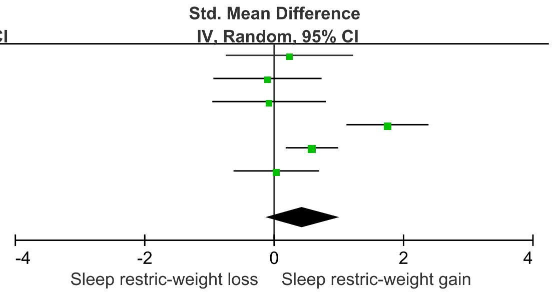

Fig. 4 Forest plot of differences of mean weight change

Discussion

To our knowledge, this is the first review including randomized controlled trials to examine the effectiveness of sleep restriction on adult body weight and actually overcomes some limitations of observational studies [3, 14, 15]. Meta-analysis of included six experimental studies with a total of 275 adults found that participants' restricted sleep duration does not result in significant weight or fat gain compared with the controlled group. The standard mean difference in body weight and body fat was 0.44 (95% CI −0.13 to 1.02) ($Z = 1.51$, $p > 0.05$) and 0.35 kg (95% CI −0.19 to 0.88) ($Z = 1.27$, $p > 0.05$), respectively. It seemed that the finding of this review does not support the causal association between sleep deprivation and obesity [3–5]. However, it is worth being noticed that three included studies indicated that restricting sleep duration significantly led to weight gain [25, 26, 28].

We analyzed the difference and found that a possible explanation was the length of interventions. Previous studies have reported that the change in body weight was achieved by changing energy stores, hydration, and alimentary tract contents [31]. The impact of sleep restriction intervention on energy expenditure can be observed in 24 h [32], but it is unclear whether the weight change can be observed in a short-term intervention length, such as 5 or 8 days [25, 26, 30]. Moreover, one study [33] conducted by Robertson et al. found that sleep restriction was associated with a weight loss during the first 2 weeks and followed by a significant weight gain within weeks 2 to 3; they also found that if extending the time, the significant weight change would decrease. This finding suggested that the impact of sleep restriction on weight change may be time-dependent, and participants are more likely to gain weight during one time period. So the long-term sleep restriction intervention is challenging to execute, but necessarily needed.

The influence of confounders may be also an explanation [34]. Insufficient physical activity and high-energy diet are two risk factors of obesity [7]. A study found that sleep restriction changed body weight through altering concentrations of plasma leptin and ghrelin. However, both hormones are directly associated with appetite and satiety mechanisms [35]. It means that eating too much energy-dense food during the daytime, the concentrations of leptin and ghrelin may be influenced, which may influence the weight change. In addition, recent study has highlighted that meal timing also influenced weight gain during sleep restriction period and participants were susceptible to consume more caloric in late night [26]. The mechanism of the effect of exercise on sleep is not clear. But, the study also has shown that exercise involves circadian alternation and homeostasis. Exercise may stimulate recovery during sleep; the drop in body temperature after exercise may promote onset latency and slow-wave sleep [36]. The finding indicated that uncontrolled diet and physical activity during sleep restriction period may shrink or exaggerate the effect size.

The lack of blinding also can explain the inconsistent result. No blinding participants and personnel for allocation may have led to the occurrence of "Hawthorne effect" [37] or introduced confounding effects in the

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Nedeltcheva 2009	1.7	0.8	11	1.5	1	11	31.0%	0.21 [-0.63, 1.05]
Nedeltcheva 2010	-0.6	0.6	10	-1.4	0.9	10	25.8%	1.00 [0.06, 1.94]
Wang 2018	-1.8	1.7	21	-1.9	2.1	15	43.2%	0.05 [-0.61, 0.71]
Total (95% CI)			**42**			**36**	**100.0%**	**0.35 [-0.19, 0.88]**

Heterogeneity: Tau² = 0.06; Chi² = 2.70, df = 2 (P = 0.26); I² = 26%
Test for overall effect: Z = 1.27 (P = 0.21)

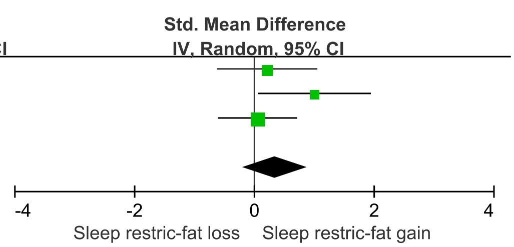

Fig. 5 Forest plot of the difference of mean body fat change

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Nedeltcheva 2009	1.9	1.6	11	2.1	2.1	11	30.0%	-0.10 [-0.94, 0.73]
O'Keeffe 2013	-0.77	0.18	27	-1.09	0.18	27	33.4%	1.75 [1.12, 2.39]
Spaeth 2013	0.97	1.4	198	0.11	1.9	27	36.7%	0.58 [0.18, 0.99]
Total (95% CI)			**236**			**65**	**100.0%**	**0.77 [-0.17, 1.70]**

Heterogeneity: Tau² = 0.58; Chi² = 14.20, df = 2 (P = 0.0008); I² = 86%
Test for overall effect: Z = 1.61 (P = 0.11)

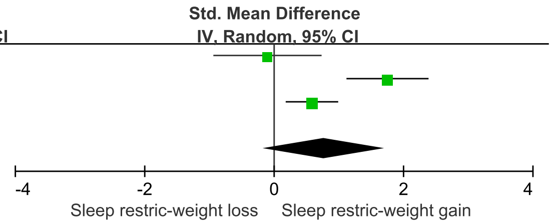

Fig. 6 Forest plot of differences of mean weight change

control group by improving interest in sleep indirectly, so that the impact of sleep duration on weight change is not observed. Moreover, one study [38] suggested that study admission procedure after screening itself may have untypical "Hawthorne effect." The enrollment depends on compliance with study requirements to collect or record data. During the period, participants are likely to strictly record their sleep or weight data and change behavior consciously or unconsciously. This participant selection procedure is necessary due to poor adherence to study requirement, but it is potential to induce bias.

The gender and race balance of samples may also contribute to the inconclusive findings. All studies were carried out in advanced countries; males and the White occupied more percentage in most selected studies. As the finding of this review, there were differences in weight change between genders and races, which has been proved by the study conducted by Spaeth that it caused by gender and racial differences in caloric intake, menstrual cycle, eating attitude, or sleep metabolic rate [39]. Observational studies have found that males were more susceptible to weight gain, resulting from sleep loss than females due to different conditions in society in daily life; males have relatively more social intercourse and they are less likely to change bad lifestyles (such as smoking and drinking), while females pay more attention to maintain their health or avoid harmful life habits [40]. Furthermore, another study reported that the educational level, the type of occupations, or marriage condition may also impact the difference in weight change [41]. It indicated that samples included the unbalanced number of gender or race may shrink or exaggerate the effect size.

Additionally, age is also a factor that may impact the results. A study found that the mean percentage of deep slow-wave sleep decreased from early adulthood (16–25 years) 18.9% to midlife (36–50 years) 3.4% [42]. A review also found that sleep efficiency, the percentage of slow-wave sleep, and rapid eye movement latency, all significantly decreased with age [43]. What's more, because of the reductions in sleep spindles as well as a reduced strength of the circadian signal, the sleep consolidation declined, time of awakening and plasma melatonin changed into an earlier time with increasing age after early childhood [44]. So, it means that although participants were assigned similar restricted sleep time among these selected studies, they may have different sleep condition during the sleep restriction period, which may lead to different body reactions and weight change because of differences in ages.

The current evidence has several limitations. First, the generalization was limited by the small number of included studies and the significant heterogeneity across the studies. In addition, this review identified related articles published from January 2005 to June 2018 in four databases; broadening the search time and databases may access more studies. We also did not include unpublished data or published in another language except English.

Conclusion

Meta-analysis of six studies found that sleep restriction interventions were not significantly effective in gaining body weight among adults [0.44 kg (95% CI −0.13 to 1.02) ($Z = 1.51$, $p > 0.05$) in a short period. However, three included studies have indicated that sleep restriction resulted in significant weight gain. No sufficient evidence to support the hypothesis from observational studies that sleep restriction leads to weight gain.

Recommendations

Future sleep restriction interventions with high quality, long-term intervention length among adults and comparison weight or BMI change between intervention group (physical activity + diet + sleep) and control group (physical activity + diet) are necessarily needed if someone wants to assess the impact of sleep restriction interventions on weight loss. In addition, balanced gender, grace in the samples, and the narrow age gap of participants between selected studies are also necessary to minimize the possible confounding effect.

Author contributions All reviewers entered every step to ensure the security and completeness of the data, if there was a disagreement, discussing together or assessing by the third reviewer to resolve.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Date sharing statement No additional data are available.

Appendix 1: search strategy used in the Ovid MEDLINE January 2005–June 2018

1. **adult$.tw (969812)**
2. **female$.tw (723552)**
3. **male$.tw (893686)**
4. **m?n.tw (1261299)**
5. **wom?n.tw (923021)**
6. **or/ 1–5 (3660745)**
7. **sleep$.tw (138539)**
8. **(sleep adj3 duration$).tw (6304)**
9. **(sleep$ adj3 tim$).tw (10550)**
10. **(bedtime or bed tim$ or time in bed).tw (4974)**
11. **(sleep$ adj3 hour$).tw (3771)**
12. **night rest.tw (53)**
13. **or/7–12 (141267)**
14. **randomi?ed.tw (471727)**
15. **non randomi?ed.tw (8828)**
16. **clinical trial.tw (101372)**
17. **randomi?ed controlled trial.pt (467664)**
18. **controlled clinical trial.pt (92598)**
19. **experiment$ study.tw (1523737)**
20. **(pre-post or prepost or pre post).tw (6905)**
21. **(posttest or post test).tw (14669)**
22. **(pretest or pretest).tw (13928)**
23. **before after.tw (3683)**
24. **(qua?i-randomi?ed or qua?irandomi?ed).tw (3589)**
25. **quasiexperimental study.tw (125)**
26. **or/14–25 (2281151)**
27. **weight (914152)**
28. **exp weight loss/ (37322)**
29. **(weight loss$ or weight-loss$).tw (66114)**
30. **(weight adj3 reduc$).tw (27861)**
31. **exp BMI/ (101940)**
32. **exp body mass index/ (11048)**
33. **or/ 27–32 (978486)**
34. **apn?ea.ti (20146)**
35. **sleep apn?ea.ti (17399)**
36. **study protocol.ti (5120)**
37. **(sleep$ adj1 disorder$).ti (5190)**
38. **OSA.ti (614)**
39. **or/34–38 (28061)**
40. **6 AND 13 AND 26 AND 33 NOT 39 (337)**

Appendix 2: data extraction form

Administration details				
Study ID (last name of the first author and publication date)				
Title of the article				
Country				
Language				
Study details				
Aim of the study				
Study design				
Setting of the study				
Duration of the study				
Methods				
Randomization				
Allocation				
Blinding				
Notes				
Participants characteristics				
Patient baseline characteristics	Total	Intervention group	Control (no supplement)	Difference between the groups
Number randomized				
Number analyzed				
Age				

Gender (M/F), *n* (%)				
Weight measure				
BMI level				
Interventions/comparators				
Intervention type				
Intervention description				
Who delivered the intervention				
Who else also involved the intervention?				
Control description				
Follow-up				
Duration of the intervention				
Numbers of participants dropped out of the study (%)	Original number	Final number	Reasons	
Time of follow-up				
Numbers of participants dropped out during follow-up (%)	Original number	Final number	Reasons	
Outcome measure and assessment				
Outcome measure method	Details:			
Outcome evaluation method	Self-report or observed measure		Details	
Outcome effect	Intervention group		Control group	
Mean change difference with 95% CI	Analyzed participants number (total)	Mean change (95% CI)	Analyzed participants number (total)	Mean change (95% CI)
Comments:				

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