REVIEW ARTICLE

A Review of the Assessment of Sleep, Body Weight Status and Their Relationship in Adults

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ABSTRACT

A lack of sleep is a modifiable risk factor for poor health, such as the risk of obesity, diabetes, hypertension, and metabolic syndrome. This article summarises significant studies that explore the assessment of body weight status and sleep quality and their association. A literature search was conducted in the electronic databases such as Google Scholar, PubMed, MEDLINE Complete at EBSCOhost and Scopus. The findings on the association between sleep quality and body weight status were inconsistent. Both short and long sleep duration were associated with obesity status. Overall, a positive relationship between sleep and obesity in adults was observed. Further research on sleep quality and its association with body weight status among adults is needed. Better health is associated with a longer and sufficient duration of sleep. Therefore, it is of great significance to enhance the public's awareness of their sleep quality on body weight status.

Keywords: Sleep quality, Body Mass Index, Obesity, Adult

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INTRODUCTION

The World Health Organization (WHO) has come out with a definition of body weight status. Weight status refers to body mass index (BMI), which is calculated as body mass (in kilograms) divided by the square of the body height (in meters). The unit used to determine BMI is kg/m^2. BMI has been commonly used to demonstrate malnutrition, either thinness or obesity, in all populations, including adults, at regional and international levels. Underweight is classified as a BMI of less than 18.5 kg/m^2; normal weight is referred to as BMI, ranging from 18.5 kg/m^2 to 24.9 kg/m^2. Furthermore, overweight ranged between 25 kg/m^2 and 29.9 kg/m^2, BMI of 30 kg/m^2, and higher falls within the obese range (1). BMI is not a precise body fat calculation, but it is more precise than calculating weight alone when estimating body fat. The BMI classes are related to the impact on mortality and morbidity of extra body fat and are relatively well linked to adiposity.

Sleep quality is described as the satisfaction of one's sleep experience, sleep maintenance, awakening refreshment, and how well you sleep (2). Good sleep quality also means falling asleep during the night in 30 minutes or less with sound sleep. The poor quality of sleep is the problem of falling asleep and remaining asleep (3). Based on the Pittsburgh Sleep Quality Index (PSQI) domain, sleep quality can be defined as a collection of sleep measures, including sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, sleeping medication use, and daytime dysfunction. Furthermore, PSQI also offers a global sleep quality assessment based on the respondent's sleep measure analysis (4).

Sleep is vital to the health of an individual and his life. It performs essential brain functions, particularly activity-related protection and neurobehaviour (5). Sleep duration is related to an increased risk of death and disorders, including obesity and cancer (6). High mortality rates and cardiovascular disease have been linked with inadequate quality and quantity of sleep. Besides, an elevated risk of psychiatric illness is also correlated with obesity and poor sleep (5).

A recent study in 2014 explored the relationship of sleep by weight status of young adults. The study found that higher Global PSQI score was significantly associated with overweight or obesity (7). Studies of US college students have also shown that overweight subjects had lower sleep quality among men whereas among both overweight and obese women respondents had poorer quality of sleep than normal weight participants (8).

A study examining the relationship between sleep and BMI in a larger sample of American adults found there was a significant indirect association between sleep quality and BMI (9). Another study found that short sleep duration and poor sleep quality was more positively associated with obesity across BMI than underweight (10). Hence, this review was conducted to determine the assessment of body weight status and sleep quality and their association. To date, there are limited studies carried out on this topic, especially among adults.

METHODS

Key search terms such as sleep quality, body mass index, obesity, and adult are used to find studies that explored the association between sleep quality and body weight status in adults. We performed electronic databases searches. A literature search of the following databases was conducted using similar MeSH keywords: Google Scholar, PubMed, MEDLINE Complete at EBSCOhost and Scopus. A comprehensive search of full-text accessibility academic journals (English) published on this topic was conducted. All types of study designs were included in the search; either an observational study like a cohort, randomized study, cross-sectional, longitudinal, and case-control study, retrospective or a prospective cohort study among adults, or reviews such as systemic review. Country, study design, participants characteristics, and findings on assessment of sleep quality and body weight status, and their association are summarized in Table I.

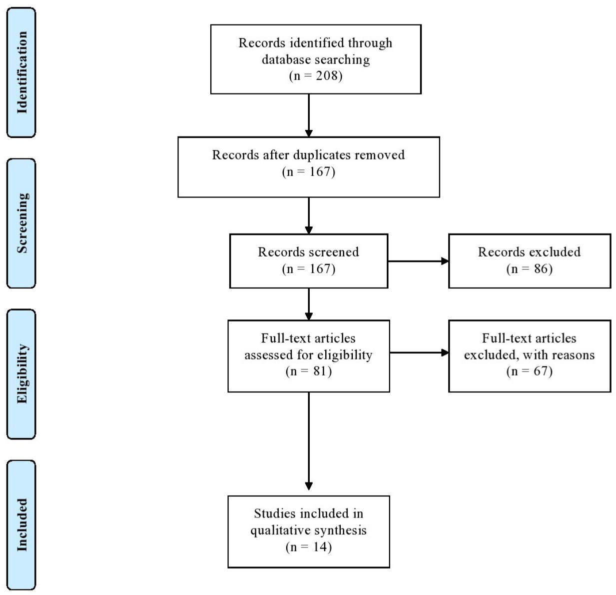

Figure 1: Prisma Diagram showing the results of the literature search

RESULTS

Assessment of body weight status

BMI and waist circumference are identification methods for predicting weight status concerning the future risk of disease. Nevertheless, BMI and waist circumference are not screening instruments for disease risk (11). A high BMI may show a high body fat level, and a low BMI may imply a low body fat level. Overweight or obesity is defined as weight greater than acceptable a reasonable weight for a given height. Underweight is classified as below what is deemed acceptable for a specific height (12). For height in inches assessed and weight in pounds weighed, the BMI equation has been modified. These quantifications can also be collected at home using a measuring tape and weighing scale or a trained healthcare provider (11). A study was conducted among 150 Malay ethnic adults aged 20 to 59 to calculate the BMI where their height and weight were measured by a trained nurse using 'Health Scale' (13). BMI has its limitations. The BMI, however, is not suitable for use in pregnant women and does not differentiate between muscle mass-related weight and fat mass-related weight.

An alternative option to quantify the possible disease risk is to calculate the waist circumference and waist-to-hip ratio. Waist circumference is positively correlated with abdominal fat (14). It is an extremely useful tool for recognising people at elevated risk of chronic diseases (15). High abdominal fat may be extreme as it puts an individual at increased risk for subsequent disorders linked to obesity, such as type 2 diabetes, high blood pressure, and coronary artery disease (16). For example, an adult man's waist circumference should not be higher than 40 inches, whereas not more than 35 inches for a non-pregnant adult woman (17). A simple metric that is irrelevant to height and corresponds with BMI is waist circumference. Both BMI and waist circumference may be utilised as an analysing instrument on an individual basis. However, the body fat or wellbeing of an individual is not diagnosed. The National Institutes of Health believes that doctors must include waist circumference in their evaluation instruments due to various BMI's potential for error, like misclassification problems that may result in important bias in estimating the effects related to obesity (18). Another study has been conducted in Terengganu involving 340 adult subjects (19). It was led to investigate the incidence of obesity and anthropometric measurements such as BMI, waist circumference (20), hip circumference, waist to hip ratio, and fat percentage (19).

Skinfold thickness assessments with callipers, underwater weighing, bioelectrical impedance, and dual-energy x-ray absorptiometry (DEXA) are other techniques for determining body composition. Skinfolds include pinching an individual's skin fold with its underlying layer of fat at different body locations (21). Using a custom-developed calliper, the fold is assessed. It can measure body fat with an error of 3% to 4% when carried out by a certified professional (22). Additionally, when fully submerged, underwater or hydrostatic weighing tests the quantity of water an individual displaces. Fat tissue is less dense than muscle or bone. Thus by evaluating weight underwater and out of the water, body fat can be

Table I: Overview of Studies in Sleep Quality and Body Weight Status

Reference **Country**	**Study design**	**Participant characteristics (n, age, sex)**	**Results**
Farah et al.[27] Malaysia	Cross-sectional study	Aged = 21 to 60 years old	Overall mean PSQI global score was 5.25. About 45% of the sample had PSQI global score >5, indicating poor sleep quality. The total sleep duration per night was 5.95 hours, below the recommended amount. Sleep quality seems to be affected by age but not gender. Findings also indicate that most of the adults in our sample were experiencing inadequate sleep; thus, further research is needed to identify the factors associated with poor sleep quality.
Liu et al.[47] Columbia	Descriptive study	Subjects; n = 444,306 adult Male = 64.6 % Female = 65.2 % Age range = 18 – 65 years old	65.2% of adult reported healthy sleep duration. Short sleep duration (<7 hours per night) is associated with greater weight gain. A sleep duration of ≥7 hours is associated with lower prevalence estimates of obesity than a short sleep duration.
Taheri et al.[49] USA	Longitudinal study	Subjects; n = 1,024 volunteers Age range = 30 – 60 years old	Participants with short sleep had reduced leptin and elevated ghrelin. These differences in leptin and ghrelin are likely to increase appetite, possibly explaining the increased BMI observed with short sleep duration. In Western societies, where chronic sleep restriction is common and food is widely available, changes in appetite regulatory hormones with sleep curtailment may contribute to obesity. Reduced sleep appears to represent a novel, independent risk factor for increased weight gain.
Brondel et al.[50] France	Experimental study	Subjects; n = 12 Age range = 18 – 29 years old BMI range = 19.0 – 24.6 kg/m^2	Sleep restriction could be a factor that promotes obesity.
Cassidy et al.[51] UK	Cross-sectional study	Subjects; n = 398,984	Increased BMI is associated with a greater likelihood of reporting poor sleep duration.
Miller et al.[52]	Systematic review & meta-analysis	Age range = Infants (0 to <3 years) Early childhood (3 to <9 years) Middle childhood (9 to <12 years) Adolescents (12 to 18 years).	The prevalence of obesity has increased worldwide in the last few decades and the World Health Organization has now declared it a global epidemic. A decrease in the average duration of sleep, alongside an increase in shift work and long work hours has been reported in westernised adult populations. Short sleep duration is a risk factor or marker of the development of obesity in infants, children, and adolescents.
Wu et al.[53] North America. Japan, Europe	Meta-analysis		About 500 million adults worldwide were obese in 2005, and this number has doubled since 1980 and is projected to increase to 1.1 billion by 2030. Short sleep duration was significantly associated with obesity, whereas long sleep duration did not affect future obesity among adults.
Baron et al.[54] USA		Subjects; n = 52 volunteers Male = 27 Female = 25	Fifty-six percent were normal sleepers, and 44% were late sleepers.
Park et al.[55] Korea	Cross-sectional study	Subjects; n = 107,718 Korean individuals Males = 63,421 Females = 44,297 Age range = 18 - 91 years	20% of the general population, short sleep duration and poor sleep quality is imposing a growing the burden on public health. Poor sleep quality was significantly associated with severe obesity in the male subgroup and obesity and severe obesity in the female subgroup. Short sleep duration and poor sleep quality were more positively associated with obesity across BMI than underweight.

Abbreviations: BMI, Body Mass Index; PSQI, Pittsburgh Sleep Quality Index.

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Table I: Overview of Studies in Sleep Quality and Body Weight Status (continued)

Reference Country	Study design	Participant characteristics (n, age, sex)	Results
Wang et al.[56] China	Cross-sectional study	Subjects, n = 1328 participants Age range = 19–23 years Male = 35.4% Females = 64.6%	249 (18.75%) were underweight, 958 (72.14%) were of normal weight, 91 (6.85%) were overweight, and 30 (2.26%) were obese. The proportion with poor quality of sleep was 36.5% for men and 39.1% for women. The sleep quality of females is probably associated with their BMI. Sleep quality in female students, but not in males were associated with BMI.
Thomson et al.[57] USA	Randomised clinical trial	Subjects; n = 245 women Aged = ≥18 years	Better subjective sleep quality increased the likelihood of weight-loss success by 33%, as did sleeping seven hours/night. A worse Global Score at six months was associated with a 28% lower likelihood of continued successful weight loss at 18 months, but not associated by 24 months.
Adбmkovб et al.[58] Czechia		Subjects; n = 3970 Male = 2038 Female = 1932 Aged = 18-65 years	The body mass index (and optimal body weight) was associated with a sleep duration of 7 hours per night. This association was found both in males and females and in both districts.
Huang et al.[59] China	Longitudinal study	Subjects; n = 7752 participants	Only short sleep duration (≤ 6 hours) significantly increased the risk of weight gain ≥ 5 kg. Sleep duration of nine hours was significantly associated with a lower risk of incident overweight/obesity.
Patel,[60] USA	Prospective longitudinal study	Subjects; n = 121 700 Married Female nurses Age range = 30–55 years old Exclusion criteria: women with cancer, heart disease or diabetes at baseline	Parallel to the rapid rise in the prevalence of overweight and obesity in Western society over the past half-century has been a steady and rapid decline in time spent sleeping. At the beginning of the 20th century, young adults obtained close to 9 hours of sleep per night, but by the late 1960s, sleep duration had been reduced to 7.7 hours. According to surveys done by the National Sleep Foundation, in 1998 only 35% of American adults were obtaining eight hours of sleep on weekdays, and that number had fallen to 26% by 2005. Conversely, the percentage of American adults obtaining less than six hours of sleep per night has increased from 12% in 1998 to 16% in 2005. The increased prevalence of obesity in Western nations over the past half-century, has been paralleled by a severe reduction in sleep duration. Reduced habitual sleep duration as assessed by self-report is an independent risk factor for an increased rate of weight gain and incident obesity. Association between reduced sleep and obesity persists when sleep habits are measured objectively, that the association is due to elevations in fat and not muscle mass and that this association is not related to sleep apnoea.
Chen et al.[61] Taiwan	Experimental studies	Subjects; n = 2,392 adults Males = 1,121 Females = 1,171	An inverse U-shaped relationship between sleep duration and BMI in women with normal weight (the 30th percentile of BMI, BMI = 21.37). A U-shaped relationship between sleep duration and BMI above the 90th percentile of BMI in men.
Pengpid & Peltzer[62] Thailand	Cross-sectional survey	Subjects; n = 860 undergraduate university students Males = 27.3% Females = 72.7% Age range = 18 - 25 years	Overall, 21.5% were underweight (<18 BMI) and 20.8% were over-weight (7.8% overweight [≥23 BMI] and 13% obese [≥25 BMI]). More than half (52.5%) had a sleep duration of 7–8 hours, 41.5% had six hours or less, 14.4% had nine hours or more, and 6% reported having moderate to severe sleeping problems. Among men, the study found that short sleep duration was associated with underweight. Factors associated with overweight and obesity are men, trying to eat fibre, and depression symptoms. The underweight risk was having a high-income background, short sleep duration, and low physical activity. Adult age 18-25 has a normal weight range (mean BMI= 20.2 kg/m^2).

Abbreviations: BMI, Body Mass Index; PSQI, Pittsburgh Sleep Quality Index.

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Table I: Overview of Studies in Sleep Quality and Body Weight Status (continued)

Reference Country	Study design	Participant characteristics (n, age, sex)	Results
Knutson,[63] Western countries	Experimental study		In 2005, more than 200 million men and nearly 300 million women were obese and this the number is projected to increase to as many as 1.1 billion people by 2030. The prevalence of obesity is not distributed equally between different socio-economic groups where those of lower socioeconomic status suffer a greater burden. For example, in the United States, the prevalence of short sleep (≤6 hours per night) is estimated to be 17–18% of adults (National Sleep Foundation 2010), which means that over 53 million people in the US are likely to be short sleepers. The accumulated evidence from experimental and observational studies suggests that inadequate sleep may play a role in the risk of obesity and vulnerability to associated cardiometabolic diseases, such as diabetes and cardiovascular disease. Through which inadequate sleep could lead to these conditions, potential pathways include impairments in appetite regulation, glucose metabolism, and sympathovagal balance.
Nicholson et al.[64] USA	Cross-sectional study	Subjects; n = 307 first-year college students Female = 84.7% Males = 15.3%	Mean BMI of 24, and 8.1% were underweight, 60.6% healthy weight, 19.5% overweight, and 11.7% were obese. The average reported wake time was 8:32 a.m. (ranging from 6:07 a.m. to 11:14 a.m.) and average reported bedtime was 12:56 a.m. (ranging from 9:12 p.m. to 3:55 a.m.). Greater differences in sleep duration from weekdays to weekends corresponded with higher BMIs. Individuals who were overweight and obese also reported significantly greater weekday to weekend and day to day sleep duration as compared to healthy weight individuals, supporting these findings.

Abbreviations: BMI, Body Mass Index; PSQI, Pittsburgh Sleep Quality Index.

measured within a 2% to 3% error range (23).

Bioelectrical impedance analysis (BIA), on the other hand, works by passing a very minimum amount of electrical flow through the body of an individual (24). Since lean body mass consists mainly of water, the rate at which electricity is carried out provides an overview of an individual's lean body mass and body fat. BIA will measure body fat under the best conditions with an error of 3% to 4% (25). Furthermore, dual-energy X-ray absorptiometry (DEXA) is just another way of assessing body fat (26). This approach distinguishes between bone tissue, lean tissue, and adipose tissue using very low-level X-rays. The margin of error for estimating body fat is 2% to 4%. (27).

In addition, the bod pod uses air displacement to calculate the composition of the body (27). This system is a large structure made of fibreglass, egg-shaped (28). In the device, the individual being weighed sits wearing a swimsuit. The door is closed, and how much air is displaced is determined by the machine. With a 2% to 3% error range, the value is used to measure body fat (29). Nevertheless, these techniques are perhaps not widely accessible. Moreover, most of these approaches can be hard to standardise through observers or devices, complicating distinctions over periods of research and time. These methods can be more effective, but they have to be performed by a qualified medical professional. Besides, they may be more costly, hard to execute on massive samples, and lack quite enough funding for scientific practice as BMI (30).

Assessment of sleep quality

Subjective measurements

There are various available self-reported instruments such as sleep diaries and PSQI. PSQI is an attested tool for measuring sleep quality. PSQI distinguishes sleep by poor and good by evaluating seven domains. Those seven components are subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, sleep medication use, and daytime dysfunction over the past 30 days. The participants self-rated each of these seven related components. A bad sleeper is indicated by a cumulative total of five or higher. A study using PSQI has demonstrated high validity and consistency in Malaysian adult populations (31).

Sleep diaries provide a subjective, regular evaluation of sleep and sleep disruption, and are required around 5 to 7 minutes to finish each day. Relevant areas analysed by diaries consisted of total sleep hours, the number of minutes needed to fall asleep, and the total number of minutes of lack of sleep when awakened (32). Moreover, another questionnaire designed to determine subjective sleep consistency is the Karolinska Sleep Diary (KSD) (33). A summary ranking of sleep quality was developed from 4 of its components from the validated Karolinska sleep diary includes sleep quality, phrased "How did you sleep?; restless sleep; sleeping problems; and premature (final) waking. The overview sleep quality index scores range from 4 to 20, at which a score of 4 is the lowest quality, and a score of 20 is the highest quality (34). The Consensus Sleep Diary (CSD) was developed, tested, and standardised to be used mainly for insomnia scientific purposes, as well as for both "good" and "poor" sleepers for clinical and scientific implementations (35).

Another sleep questionnaire instrument used to measure sleep quality is the Epworth Sleepiness Scale (ESS). The ESS is a self-administered questionnaire with eight short and simple questions. The respondents have to rate each question on a scale of zero to three when involved in eight separate tasks, their normal likelihood of dozing off or falling asleep. The greater the ESS rating, the greater the average daytime sleepiness of an individual. It might only take no longer than two or three minutes to answer the questionnaire (36). Since PSQI and ESS item ratings are based on subjective data, bias sources may affect outcomes accuracy.

Furthermore, the Groningen Sleep Quality Scale is intended to demonstrate the previous night's sleep quality (37). On the other hand, the Insomnia Severity Index also measured subjective sleep disruptions during the past week (ISI). A calculation of seven domains measures the perceived seriousness of insomnia and daytime discomfort caused by insomnia (38). The score represents a cumulative score with specific cut-off points showing the extent of insomnia as follows, 0-7 (no clinically relevant insomnia); 8-14 (sub-threshold insomnia); 15-21 (moderately serious clinical insomnia); 22-28 (severe clinical insomnia) (32). In a clinical study, the ISI demonstrated strong internal consistency (alpha = 0.74) and high reliability (alpha = 0.83) (38).

However, other common assessments, such as the Athens Insomnia Scale (AIS), analyses problems with falling asleep or sustaining sleep (39). Two distinct methods of self-reported assessments are sleep questionnaires and sleep diaries. Since sleep questionnaires are conducted at a once in time and retrospectively inquire about different aspects of sleep experience over a longer time, sleep diaries are current, daily self-monitoring resources (37). Due to methodological variations, the two assessment forms tapped the same items but led to varying outcomes (37). This is because questionnaires may be prone to memory distortion, whereas atypical sleep experiences during the monitoring period can affect sleep diaries (40).

Objective measurements

On the other hand, sleep study or polysomnography (PSG) is a non-invasive test that monitors brain and body activity. However, this exam will be held in a sleep lab where the clients must stay overnight there. The data obtained from the client is not more than two weeks. While the client is sleeping, PSG measures eye movements, brain, muscle function, airflow and respiratory effort, blood oxygen levels, body positioning, and movements, snoring, and heart rate (41).

The actigraphy is placed on the non-dominant wrist like a watch and by the operation of light and motion tracks (42). For tracking human sleep or wake cycles, actigraphy or accelerometry is widely used. Low prices, widespread accessibility, simple logging of multiple nights, and less troubled natural sleep are actigraphy strengths. Its precision, however, varies across different sleep variables and depends on population-specific features (43). Actigraphy helps to determine overall sleep time and alertness after sleep (44). Actigraphy data can help assess circadian rhythm disorders, such as advanced or delayed sleep phase disorder and insomnia (45).

Spectral analysis of non-REM (NREM) offers measures of the frequency quality of EEG signals transmitted throughout NREM sleep (46). It has been assumed that an indication of "bad" sleep is a higher high-to-low EEG frequency ratio at sleep (47). These results indicate that NREM EEG spectral indices could significantly impact sleep quality scores as objective indicators. Nevertheless, for this approach, very little analysis was done, and the techniques have yet to be validated.

A manualised indicator of NREM sleep system uncertainty derived from PSG results is the CAP rate (48). It has been assumed that the CAP rate represents the pathways that underlie the state of stimulation while sleeping (48). Enhanced CAP levels have been reported in people with constant acoustic interference (49). In research of primary insomnia patients diagnosed with effective therapies versus placebo, the CAP rate was a significant predictor of 'sleep efficiency' scores (50). The main drawback of CAP is that very little research has been reported to date.

DISCUSSION

Association between sleep quality and body weight status

Sleep duration (≥ seven hours) is linked with the increased cessation of cigarettes. However, increased sedentary lifestyles and a greater risk of obesity are associated with long sleep duration (51). Besides, sleeping more than 9 hours a night routinely can be suitable for young adults and people who recover from insufficient sleep and persons with diseases. For many others, it is unclear if sleeping more than 9 hours a night is correlated with health risk (5). Contrarily, in another study, short sleep duration, less than seven hours each night, is correlated with reduced insulin sensitivity, increased metabolic dysfunction, and body weight gain, leading to diabetes mellitus and unfavourable cardiovascular complications (52). The study also revealed that more than one-third of US citizens are generally sleeping less than seven hours a day and putting them at higher risk of negative health effects (52).

A decline in the length of sleep has been reported in developed countries over the past 40 years, along with an increase in obesity. A recent analysis in 1024 volunteers in the USA found that in those aged 30 to 60 years who recorded an increase in BMI from 31.3 kg/m^2 to 32.4 kg/m^2, the mean sleep duration at every night reduced from eight hours to five hours, as calculated by the respondents with available data from sleep diary at average age (53.1 years) and sex discrepancy (54.4% male). Escalated BMI was corresponding to reduced sleep, the longitudinal study indicates (53). In this same study, the usual duration of sleep fewer than 7.7 hours was linked with greater BMI, decreased leptin was correlated with sleep duration, and enhanced ghrelin was found. This proves that poor sleep is interrelated with higher BMI (53). A similar finding was observed in Brondel et al., which enrolled 12 males aged 18 to 29 (54). A more extensive study is suggested to examine a large sample size with randomly selected gender.

Furthermore, previous research involving adults in the UK demonstrated that low sleep duration, less than seven hours or more than eight hours per night, was more remarkable in overweight and obese than normal-weight people (55). Besides, with 72% of normal-weight adults reporting seven to eight hours of sleep a night and just 54.5% of obese III adults indicating equivalent sleep duration, good sleep duration deteriorated within BMI categories. This outcome indicates an association between increased BMI and greater chances of having insufficient sleep duration (55). The study is more attractive as it had included a significant sample population, which allows precise correlation.

A few experimental research types on the connection between sleep and body weight status, the risk factor or predictor of the progression are short sleep period, obesity in infants, teens, and adolescents (56). The study of the link between sleep and the body weight status discussed above showed that obesity was associated significantly with short sleep duration. However, long sleep duration did not affect future obesity in adults (57). Similarly, another study figured out that sleep duration was associated with obesity (58). The mean BMI was 23.7 kg/m^2 for normal sleepers and 26.0 kg/m^2 for late sleepers, respectively. The BMI ≥30 kg/m^2 was registered by a more significant percentage of late sleepers; however, it was not statistically significant. BMI was associated favourably with the timing of later sleep. In subjects with shorter sleep durations, there was a trend for a higher BMI. In short, shorter sleep periods and later sleep timing were correlated with higher BMI (58).

Park and his co-researchers found that low sleep quality was significantly correlated with severe obesity in male and female subgroups. Short sleep time and low sleep quality were also more favourably correlated with BMI obesity than underweight (59). Typically, the literature on the relationship between sleep duration and weight changes has examined that females' sleep quality is likely correlated with BMI. As indicated, sleep quality was related to BMI in female students but not in males (60). These findings suggest that the influence of poor sleep quality on obesity may be more powerful in women than men (59). Furthermore, female students may be more sensitive to problems with sleep quality and BMI (60). Further study is needed to provide prospective researchers with a compilation of preliminary information on the sex difference between sleep quality and obesity.

On the other hand, females who recorded sleeping less than seven hours each night were substantially less likely than females who graded more than seven hours each night to reach meaningful weight loss. Moreover, women with a low sleep quality score of more than zero were substantially less capable of attaining sufficient losing weight than females with zero in subjective sleep quality. Women who registered an "excellent" quality sleep score or an average night sleep period of more than seven hours demonstrated a reasonable probability of sustaining weight loss effectively at 12 and 18 months loss (61). This study is more useful as they had focused on PSQI, a well-known instrument that has been validated in various sample sizes. Generally, PSQI Global Sleep Scores of more than five were related to a lower probability of successful weight loss for long the term (61,62).

The study, which enrolled 7752 participants, found that only a short duration of sleep (≤ six hours) remarkably elevated the probability of putting on weight ≥ 5 kg. Between six hours and seven hours, short sleep time substantially enhanced the weight gain risk in 45 years alone by about 5 kg. For participants < 45 years of age, the risk of weight gain of more than 5 kg was significantly increased by just a short sleep period (about six hours). Conversely, no clear relationship was observed between long sleep duration, more than ten hours, and the chance of weight gain ≥ of 5 kg (63). Perhaps the most significant downside of this research is that there was a potential bias due to the lack of follow-up. Therefore, this study found that a short sleep period is a contributing reason driving weight gain in Chinese adults of about 5 kg and overweight or obesity, although a lengthy sleep period did not affect future obesity.

Over the past half-century, a substantial decline in sleep duration has preceded the growing incidence of obesity in Western countries. As measured by self-report as an independent predictor for a high weight gain and occurrence obesity frequency, a shortened periodic sleep duration was correlated with 121,700 married female nurses ranging in age 30 to 55 years. In this research, when sleep patterns are measured objectively, a correlation between decreased sleep and obesity exists, that the association is due to elevations in fat and not muscle mass, and that this relationship is not related to sleep apnea (64).

Findings from an experimental study showed an inverse U-shaped relationship in women with a normal weight. This indicates that there may be extra time to focus on physical activity for short sleepers. Short sleepers are also used to do more vigorous physical exercise than the average sleepers' sleep duration in either men or women is not significantly correlated with BMI. This result indicates that women of average weight, those who sleep longer, are best placed to rest. Therefore, during their awakening phase, they are more productive and expend more energy. On the other hand, this outcome shows a U-shaped association between sleep duration and BMI above the 90th percentile of male BMI. However, these links can only be relevant in obese males (65).

Furthermore, a recent analysis in 860 undergraduates in Thailand found that those aged 18 to 25 who recorded short sleep duration were associated with underweight in men (66). In contrast, normal sleep duration, which is seven to eight hours of sleep duration, was associated with overweight and obesity among women (66). Conclusive evidence from longitudinal and observational research indicates that the risk of obesity and susceptibility to related cardiometabolic diseases such as diabetes and cardiovascular disease may be impaired by insufficient sleep. A possible mechanism by which insufficient sleep may lead to these conditions' growth includes abnormalities in the control of appetite, glucose metabolic processes, and sympathovagal balance (67).

Not all studies have observed similar effects on body weight status. Recent research in first-year college students showed that opposite patterns with BMI are shown by nightly sleep and daytime sleep (68). Nevertheless, there was no significant association between total sleep duration, which collapses across nightly and daytime sleep, and BMI. The results also showed that higher variability in sleep duration from weekdays to weekends corresponded to higher BMI. This study also found that overweight and obese students, relative to healthy weight students, also showed a substantially wider length of a weekday to weekend and day-to-day sleep. Therefore, as reported in the literature, shorter nighttime sleep and longer nap periods are linked to increased BMI values (68). This study's main weakness is that daily diary approaches depend on the precision and continuity of subjects who record their sleep behaviours themselves. Difficulties arise, however, when the participants were less likely to complete the weekend sleep data.

Short sleep duration and poor sleep quality are popular in the adult population. A direct relationship between sleep and obesity across BMI should not be assumed. Low sleep quality was significantly correlated with higher BMI. Longer sleep duration was statistically significantly associated with increased risk of overweight and obesity. The summary of the studies is shown in Table I.

CONCLUSION

This review provides strong evidence that obesity and particularly overweight among adults are associated with poor sleep quality and shorter sleep duration. However, the association between body weight status and sleep quality in adults is not clear as many studies do not explain the mechanism of how sleep quality affects weight status. Hence, more research needs to provide baseline data for future researchers and enhance the public's awareness of their sleep quality on body weight status to improve sleep issues as well as holistic mental and physical health.

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