REVIEW

An Integrative Review of Sleep for Nutrition Professionals[1,2]

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ABSTRACT

Sleep is an essential lifestyle factor that contributes to overall health. The inverse relation between sleep duration and weight status has revealed the importance of sleep in nutritional health. This integrative review builds foundational knowledge with regard to sleep vis-à-vis nutrition by summarizing the importance and process of sleep, current sleep recommendations and trends, as well as lifestyle contributors to poor sleep. Additionally, it details the association between sleep and obesity and potential mechanisms for this association. Furthermore, guidance is offered regarding the incorporation of sleep considerations in nutrition counseling, communication, and research. Like many other lifestyle factors that contribute to nutritional health, sleep needs to be considered when examining weight management and health promotion. *Adv Nutr 2014;5:742–759.*

Introduction

Sufficiently long, restful sleep sessions each night are an indisputable cornerstone of good health (1). Yet, despite its importance and the fact that we spend >30% of our lives sleeping, few people, including many health care professionals, have formal opportunities to learn about the process of sleep and its impact on health. Recently, links between sleep and weight status have emerged; therefore, nutrition professionals need to include sleep quality and duration in health assessments and lifestyle modification interventions as part of nutrition therapy and research.

The aim of this integrative review is to build foundational knowledge regarding sleep for the nutrition professional. The overall process and importance of sleep are discussed along with current sleep trends in the United States. Evidence surrounding the association between sleep and weight status is reviewed along with the proposed mechanisms supporting these associations. Contributing lifestyle factors associated with inadequate sleep are reviewed. Additionally, strategies to incorporate sleep into nutrition assessment and health promotion are included.

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Why Is Sleep Important?

In and of itself, sleep is important for neurological processing and physiologic restoration. Sleep imparts mental and physical health benefits. The studies evaluating the effects of sleep deficiency or deprivation on health indicate that sleep affects emotional well-being, cognitive function, daytime performance, and physical health (2).

Because sleep is essential for survival, animals deprived of sleep die within a few weeks due to negative changes in immune, metabolic, and endocrine functions (3). In humans, partial sleep restriction alters sympathetic nervous system activity, impairs glucose tolerance, and alters hormonal levels (3–5). Short sleep duration (<7 h/night) is associated with higher risk and incidence of cardiovascular disease and poor cardiovascular health outcomes, including hypertension, hypercholesterolemia, myocardial infarction, and cerebrovascular accident (6). Inadequate sleep also is associated with increased inflammation that overwhelms the immune and antioxidant systems within the body (3). Evidence suggests that these effects can be reversed by attaining adequate sleep (3).

Inadequate sleep has been associated with heightened emotional reactivity and reduced attention, memory, and executive cognitive function (7). The reduction in psychomotor and cognitive speed that accompanies sleep deprivation increases the risk of accidents and injuries (8). Mainly due to daytime fatigue and sleepiness, the impaired cognitive

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function that results from inadequate sleep is comparable to impairments caused by excessive alcohol consumption (9,10).

What Happens When We Sleep?

Sleep is a period of physical and mental rest during which decision making and consciousness are partially or totally suspended and bodily functions are slowed but readily reversible on waking (11). Sleeping and waking, like many other bodily functions, are cyclical in nature. The 24-h circadian rhythm sustained by the human body includes the physiologic changes between sleep and wake cycles. The term "circadian rhythm" refers to the feedback loop within our bodies that orchestrates physiologic synchronizations with environmental cues associated with the regular 24-h cycles of day and night (12). For example, the onset of darkness along with withdrawal of light is an important exogenous factor that contributes to sleep (13), in part by promoting the release of the hormone melatonin from the pineal gland (14). Increased melatonin concentrations in the circulation induce feelings of sleepiness and coincide with a decrease in body temperature (14). Exogenous melatonin supplements (5–8-mg doses) have been indicated in normalizing sleep patterns and enhancing sleep quality in short-term trials (14). In addition to melatonin, increased concentrations of adenosine at and around the blood-brain barrier are observed at sleep onset (15). Adenosine is speculated to be a by-product of adenine nucleotide breakdown that occurs during waking hours. When aligned with adenosine receptors, adenosine promotes sleep (15).

During sleep, systemic changes in physiology occur, including alterations in brain-wave activity along with decreases in heart rate, blood pressure (1,16,17), respiration, and blood oxygen saturation (16,18). Body temperature also decreases with sleep (1,19). These physiologic changes decrease energy expenditure and help initiate and sustain sleep.

The 2 main types of sleep include non–rapid eye movement (NREM)[6] and rapid eye movement (REM) sleep. Although eye movement is detected in both types, its rapid nature in REM sleep indicates a dream state and increased memory consolidation (1). NREM is characterized as a dreamless period that is divided into 4 stages in which the majority of sleep time occurs. Stages 1–4 are numbered in ascending order of depth of sleep designated by changes in brain-wave activity. Stage 1 of NREM occurs first and is considered a relaxed state; it is the lightest and most easily disturbed stage of sleep and accounts for 2–5% of total sleep time (1). It is followed by stage 2 sleep, which is a deeper sleep stage and accounts for the largest amount of total sleep time (45–55%). Stages 3 and 4, commonly called "deep sleep" or "slow-wave sleep," follow in succession and occur mostly in the first third of the nocturnal sleep session (1). In a healthy nocturnal sleep session, REM sleep accounts for nearly a quarter of total sleep time (1) and starts to occur after the first hour to hour and a half after the onset of sleep (20).

Each of the NREM stages and REM sleep occur for a few minutes in succession in a sleep cycle and a nocturnal sleep session consists of ~5–7 sleep cycles (1,20). Movement through the different stages of NREM sleep and through REM sleep is a component of "sleep architecture," a term used to describe the organization of sleep stages within a sleep session (1). The following is an example of sleep architecture over a 7-h sleep session, obtained from a hypnogram, for a normal adult: sleep onset; NREM stage 1, 2, 3, 4, 2, 3, 4, 2; REM; NREM stage 1, 2, 3, 4, 3, 2; REM; awake; NREM stage 1, 2, 3, 4, 3, 2; REM; NREM stage 1, 2; awake; NREM stage 1, 2, 3, 4, 3, 2; REM; NREM stage 2, 3, 2 (20). Notice in this example that REM sleep is prefaced by a return to stage 2 sleep from the slow-wave sleep stages and can be followed by either NREM stage 1 or 2 sleep or an awakening (20). Awakening from REM or NREM stage 1 or 2 is normal for healthy adults (20). This example reveals the progressive order through the sleep stages but does not reveal the duration of time spent within each stage. It is important to understand that as the nocturnal sleep session continues, the duration of NREM stage 3 and 4 sleep decreases whereas the duration of REM sleep increases (1,20).

Sleep architecture changes with age. For instance, as children become adults, less time is spent in REM and NREM stages 3 and 4, whereas more time is spent in bed before falling asleep (referred to as increased sleep latency) and awake after initially falling asleep (1).

How Much Sleep Do We Need?

The National Sleep Foundation (NSF) sleep duration recommendations differ for each stage in the life cycle. As shown in **Table 1**, the discrepancy between actual vs. recommended sleep duration begins early in life (21). It is common for sleep duration to decrease dramatically from infancy to adolescence because of developmental changes and later bedtimes (22). Despite this decline in need for sleep, inadequate sleep duration is common at almost all ages (21,23–25).

The average nightly sleep duration in U.S. adults (6 h and 31 min) is significantly lower than the perceived amount of time needed for optimal functioning during the day (7 h and 13 min) (25). Not only is there a discrepancy between the duration of sleep time believed to be needed and the duration

TABLE 1 Sleep duration recommendations and practices

Life stage	Age	Recommended sleep duration in hours (203)	Mean sleep duration (reference)
		h	*h*
Newborns	0–2 mo	12–18	12.8 (23)
Infants	3–11 mo	14–15	12.8 (23)
Toddlers	1–3 y	12–14	11.7 (23)
Preschoolers	>3–5 y	11–13	10.4 (23)
School-aged children	6–11 y	10–11	8.9 (21)
Young teens	12–14 y	8.5–9.5	8.1 (21)
Older teens	15–17 y	8.5–9.5	7.6 (21)
Adults	≥18 y	7–9	6.5 (25)

[6] Abbreviations used: ICSD, International Classification of Sleep Disorders; NREM, non–rapid eye movement; NSF, National Sleep Foundation; REM, rapid eye movement; RMR, resting metabolic rate; TEE, total energy expenditure.

actually obtained but this latest average sleep duration is slightly lower than the 2005 NSF poll result of 6 h and 48 min (26). A downward trend has been observed for those reporting that they sleep ≥8 h/night, from 38% in 2001 to 26% in 2005 to 21% in 2013 (25,26).

Not only is sleep duration on a declining trend, but sleep recommendations have been decreasing as well (27). A review of 32 sets of sleep recommendations made since 1897 found that recommended sleep time decreased an average rate of 0.71 min/y (27). This is equivalent to a reduction of >80 min since 1897. As evidence mounts, sleep duration recommendations can be more firmly based on findings associated with reduced health risks and increased performance (28).

Why Don't We Get Enough Sleep?

Even though the majority of adults are aware of the important effect sleep has on mood, health, performance, and behavior, many adults and their children do not get the recommended duration of sleep each night (29). Several lifestyle factors are contributors to poor sleep conditions because they are believed to disrupt circadian rhythms. Circadian rhythms, as described above, are believed to be vital to our physiologic functions, including sleep. Alterations in environmental cues through lifestyle factors such as caffeine consumption and timing of sleep may negatively affect circadian rhythms, potentially leading to negative physiologic consequences (12). The most well-represented lifestyle factors in sleep literature include caffeine consumption, cigarette smoking, electronic media exposure, exposure to bright lights during dark night hours, and timing of sleep. The evidence supporting the connections between these lifestyle factors and poor sleep is reviewed here. Additionally, the 2 lifestyle factors that are designated as sleep disorders, jet lag and shift work, are discussed.

Before moving on to the specific lifestyle factors that were reported to alter sleep quality, it is important to recognize the social and behavioral aspects related to human sleep reduction. Very little research has examined these aspects, but most nutrition professionals can attest to the presence of voluntary disregard for physiologic cues by their clients, patients, and/or human subjects. In the same manner that individuals can ignore hunger and satiety cues (30), they can also ignore sleep-related physiologic cues. Social pressures such as work-related stress and overcommitment may lead to intentional sleep reduction. These factors, as well as the lifestyle factors discussed below, should be considered by nutrition professionals.

Caffeine consumption

Caffeine increases alertness by antagonizing adenosine receptors; not surprisingly, this function of caffeine also leads to a diminished inclination to sleep (31). A review on the effects of caffeine on sleep concluded that a strong association exists between daily caffeine intake and sleep issues in a wide array of study populations (32). Even a small amount of caffeine consumed regularly was correlated with disruption in sleep duration, onset, and perceived quality (32). Studies in children (33), high school students (34), and middle-aged adults (35) all revealed that caffeine consumption during the day disrupted nighttime sleep, which led to increased daytime sleepiness. A 2010 CDC report on military personnel in combat environments indicated that regular consumption of caffeinated energy drinks led to reduced sleep duration, reduced sleep quality, and increased likelihood of falling asleep during guard duty and briefings (36). Contrary to popular notions, evidence indicates that caffeine consumption has deleterious effects on healthy sleep patterns and can consequently cause daytime sleepiness. Current evidence does not delineate a specific time in which caffeine can be consumed in order to avoid disrupting sleep but indicates that caffeine consumption overall may reduce sleep quality and should be avoided by individuals complaining of sleep issues.

Cigarette smoking

First- and second-hand cigarette smoke are associated with poor sleep duration and quality. A study in preschool-aged children in Hong Kong revealed that exposure to second-hand smoke at home increased the risk of snoring (37). In adults, smoking has been associated with disturbed sleep architecture, sleep fragmentation (waking multiple times during a nocturnal sleep session), increased sleep latency, and shorter sleep duration (38–41).

Decreased oxygen saturation associated with apnea (cessation of breath) or hypopnea (reduction in breath) was observed in cigarette smokers (42,43) and can lead to awakening from sleep (44). However, there is mixed evidence surrounding impaired ventilation and oxygen desaturation in smokers vs. nonsmokers. Two separate studies indicated that apnea and hypopnea during sleep are just as common in smokers as in nonsmokers (42,43). These authors suggest that the sleep disturbances experienced by smokers may be associated with multiple factors that cause arousals throughout the night.

Arousals are undesirable transitions to lighter sleep stages or awakenings. Arousals associated with cigarette smoking include the behavior of waking to smoke during sleep hours (45), sleep bruxism (grinding teeth during sleep), and decreased oxygen saturation, which all lead to disruption of the sleep process and poor sleep quality. One study examined a large group of adults (n = 2019) living in Canada and revealed that smokers were at a higher risk of sleep bruxism than were nonsmokers; however, the risk of restless leg syndrome did not differ between these 2 groups (46). Improved sleep quality can be added to the long list of the benefits of smoking cessation.

Electronic media exposure

Numerous studies have concentrated on the relation between electronic media exposure and reduced sleep duration as well as daytime sleepiness. The use of television, computers, and video games during evening hours has consistently been linked to short sleep duration and poor sleep patterns in infants and toddlers (47,48), children (33,49–52), adolescents (51,53), and adults (51,54,55). The available evidence does not indicate a clear mechanism of causation, yet several theories have been suggested.

Aside from the effects of the light emitted from electronic media devices, which is discussed in detail below, the content of the media may stimulate a stress response through evocation of excitement, fear, and other emotions. A study in preschool-aged children reported that not only did the use of evening media directly relate to sleep problems at night but that daytime media with violent content was strongly associated with nighttime sleep problems (47). The authors suggested that the children may have been thinking about the violent content at bedtime (47). The use of media has not been deemed an effective sleep aid contrary to its increased use by adolescents for this very purpose (53). In fact, adolescents who used media devices as sleep aids had shorter sleep duration and reported more daytime sleepiness (53).

A decrease in physical activity often is associated with an increased duration of media use. A recent review concluded that an inverse relation exists between duration of screen time and duration of physical activity during childhood (56). Physical activity appears to support healthy sleep patterns in various populations (57–62) and is discussed in greater detail later in this review.

Altered exposure to light

Bright light from many media displays could counteract the natural effect of darkness on sleep initiation and maintenance. One study evaluated the effects of bright vs. dim visual media displays on several sleep-related measures in 7 men (55). The effects of the media content also were examined by using exciting and boring media tasks in both bright and dim light display conditions. Stimulating content in both bright and dim conditions significantly curbed natural nighttime decreases in body temperature and heart rate as well as inclinations to sleep (55). With the boring content, bright displays attenuated the natural nighttime decrease in body temperature, whereas the dim displays did not (55). This provides evidence that exposure to bright light displays or engaging content will circumvent physiologic sleep processes. Exposure to bright light at night is associated with insomnia and increased daytime sleepiness in children as well as adolescents (51). Bright light also was associated with decreased melatonin secretion (63,64); however, other mechanisms may also be responsible for this relation.

Timing of lifestyle behaviors

Inappropriately timing our lifestyle behaviors will disturb circadian rhythms, leading to altered physiologic responses such as poor sleep. For example, caffeine intake or engaging in physical activity immediately before bedtime may disrupt sleep. At this time, no evidence could be located that indicated that the timing of dietary intake is related to sleep quality. However, there is evidence that restricting sleep led to increased intake during late-night hours (65). Additionally, adults involved in a weight-loss intervention lost less weight if they ate lunch after 1500 h compared with those who ate lunch earlier (66). So, it is possible that the intake of meals and snacks must be appropriately timed to enhance circadian rhythms that regulate sleep and vice versa.

The timing of sleep may be an important factor to consider when encountering individuals with complaints of poor sleep. Late bedtimes have been associated with increased intake of energy-dense, nutrient-poor foods in children and adolescents (67) as well as in adults (68). Intentionally delaying sleep was shown to alter the transcription of DNA associated with various physiologic processes (69). Many experts agree that a consistent bedtime early in the dark-night hours is preferable and recommended for individuals complaining of sleep issues.

Sleep disorders

Those who are unable to improve sleep quality through healthy lifestyle changes may suffer from a sleep disorder and require professional attention. The International Classification of Sleep Disorders (ICSD), published by the American Academy of Sleep Medicine, is the authoritative text for sleep experts (44,70). Eight categories of sleep disorders are defined in the ICSD text: insomnias, sleep-related breathing disorders, hypersomnias, circadian rhythm sleep disorders, parasomnias, sleep-related movement disorders, isolated symptoms/unresolved issues, and other sleep disorders. **Table 2** reviews the 6 well-defined categories. Two commonly encountered sleep disorders in the general adult population are shift-work sleep disorder and jet lag.

Shift-work sleep disorder. As shown in Table 2, shift-work sleep disorder is a circadian rhythm sleep disorder defined by the ICSD. "Shift work" describes a shift of working hours (e.g., 1700–0100 h and 0100–0900 h) vs. typical daytime working hours (e.g., 0900–1700 h). Shift work allows for 2 additional 8-h shifts or rotation of employees within a 24-h period of time. The 2010 National Health Interview Survey indicated that nearly 30% of all U.S. workers engage in shift work (71). Shift workers report higher use of sleeping medication than their daytime working counterparts (72). There is a common presence of several sleep-related symptoms related to shift work, including shorter sleep duration, difficulty falling asleep, and sleepiness during working hours (73). Lowden et al. (74) reviewed the diet-related literature with regard to shift work and reported that compared with day workers, shift workers had similar total energy intakes but the quality of food, temporal distribution of intake, and amount of food differed. Some of the factors that were observed to affect the irregular intake patterns of night-shift workers included the lack of a social component associated with meals, work schedule conflicts with intake pattern, increased availability of snack and convenience foods, and increased rate of eating in the work environment (74). These alterations in intake patterns may be associated with the increased incidence of nutrition-related health problems observed in night-shift workers, such as gastrointestinal conditions, dyslipidemia, development of obesity, and impaired glucose metabolism (74).

TABLE 2 Sleep disorders

Sleep disorder category (reference)	Description	Examples
Insomnia (204)	Insufficient sleep on a nightly basis often accompanied by impaired social and occupational functioning	Mild insomnia, moderate insomnia, severe insomnia
Sleep-related breathing disorders (204)	Reduction in blood oxygen saturation during sleeping hours due to reduced oxygen consumption and/or decreased ventilation	Obstructive sleep apnea, central sleep apnea syndrome, central alveolar-hypoventilation syndrome
Hypersomnia (204)	Excessive daytime sleepiness or prolonged duration of nighttime sleep; compulsion to engage in multiple daily naps, often at inappropriate times such as during work, while eating, while having a conversation	Recurrent hypersomnia, idiopathic hypersomnia, post-traumatic hypersomnia
Circadian rhythm sleep disorders (204)	Sleep disorders related to the timing of sleep within the 24-h day; can be due to neurological disorders or due to voluntary disruption of sleep cycle	Jet lag syndrome, shift-work sleep disorder, irregular sleep-wake pattern, delayed sleep-phase syndrome
Parasomnia (204)	Expressions of the central nervous system that disrupt nighttime sleep	Arousal disorders, sleep-wake transition disorders, sleep bruxism (teeth grinding), sleep enuresis (bed-wetting)
Sleep-related movement disorders (204)	Repeated movement of limbs or undesirable sensation in limbs leading to disruption of nighttime sleep	Periodic limb movement disorder, restless legs syndrome

Jet lag. Jet lag is another common circadian rhythm sleep disorder in our society. Traveling across time zones affects the synchronization of our sleep-wake cycle. Common signs and symptoms of jet lag include fatigue, confusion, mood irregularities, inability to obtain adequate sleep, loss of appetite, and headaches (75). Those who travel frequently for work or as a career (e.g., pilots, flight attendants, couriers) are at increased risk of chronic jet lag, which can lead to reduced cognitive capacity and increased cortisol concentrations (76).

Why Is Sleep Important for the Nutrition Professional?

Sleep and body weight

Obesity and diabetes are major public health problems, and inadequate sleep duration and quality may be contributing factors (77–82). Improvements in sleep duration have been observed with weight loss (83), and reduced weight status is associated with healthy changes in sleep patterns (84,85). Numerous reviews and meta-analyses reporting an inverse relation between sleep duration and weight status have been published (51,56,86–99). The key findings within these reviews and meta-analyses are included below. Additionally, the effects of sleep on glucose metabolism are briefly reviewed.

Cross-sectional observations. The definition of short sleep duration varies widely in the literature depending on the study population, ranging from <4.5 h/night in middle-aged adults in the United States (100) to <12 h/night in 5-y-old children in France (101). As shown in **Table 3**, inverse relations between short sleep duration and higher weight status were observed in adults aged 18–65 y old (100,102–108) and in children aged 2–14 y old (78,101,109–116). Although the relation between sleep and weight status has been studied mainly in the United States, similar inverse relations were observed in studies from Australia (117), Canada (106,109), China (111), France (101), New Zealand (118), Norway (108), Saudi Arabia (80), Sweden (116), and various other parts of Europe (113). These findings across nations suggest that the strong association between short sleep duration and elevated weight status are universal and not unique to a particular culture.

Gender may affect the sleep-weight association (Table 3). Inverse relations between sleep and weight status were observed to a greater extent in males than in females across the life span (88,109,119–124). These observed gender differences may be attributed to general sleep duration and quality differences among males and females. For instance, Roehrs (125) reported that in a 2-d sleep study, men had lower sleep quality, more sleep disturbances, and a higher percentage of stage 1 NREM sleep than women. However, contrary observations were made by St. Onge et al. (126) who reported a more pronounced inverse relation between sleep duration and weight status in women than in men aged 33–45 y old.

A few studies reported U-shaped associations between sleep duration and weight status (127–129), indicating that too much sleep (≥9 h/night) as well as too little sleep (≤5 h/night) are associated with increased risk of overweight status in adults. A gender effect also was observed with this type of association because 2 additional studies reported finding a similar U-shaped association in female adolescents but not in male adolescents (130,131) (Table 3).

Some studies reported an absence of a relation between sleep and weight status for specific subgroups (see Table 3). Lumeng et al. (110) found an inverse relation between short sleep duration and weight status in sixth-grade children, but no association was observed in third-grade children. Similarly, Hiscock et al. (114) reported an inverse relation between these 2 factors in 6- and 7-y-olds but not in 0- to 5-y-olds. In another study, this inverse relation was observed in fifth- to eighth-grade children but not in ninth to twelfth-grade children (115). A study using NHANES data reported an inverse relation in individuals 32–49 y of age but not in older age groups (102). Age of the subject population may explain the differences found within each of the studies. Yet, no association between sleep and weight status was seen in another study evaluating 32-y-old adults (118). Differences in study design, study population, and method of sleep assessment

TABLE 3 Summary of sleep and weight status studies[1]

Key observations (reference)	*n*	Age range	Female	Region
		y	%	
Inverse relations between sleep and weight status				
Less than 10 h sleep/day was associated with increased risk of obesity (101)	1031	5–6	49	France
Risk of obesity was significantly greater with fewer hours of sleep (78)	383	11–16	54	U.S.
Less than 7 h sleep/night was associated with increased likelihood of obesity compared with ≥7 h sleep/night (102)	3682	32–49	68	U.S.
Overweight and obese subjects obtained less sleep than normal-weight counterparts (103)	924	18–91	65	U.S.
BMI was highest for those with < 6 h sleep/night and lowest for those with ≥9 h sleep/night (104)	990	≥18	52	U.S.
Those sleeping 5–6 h/night weighed more than those sleeping ≥7 hours/night (105)	68,183	39–65	100	U.S.
8–10 hours of sleep/night was associated with significantly higher odds of obesity than 12–13 h sleep/night (109)	422	5–10	50	Canada
BMI was significantly higher with 5–6 h sleep/night compared with 7–8 h sleep/night (106)	276	21–64	53	Canada
Seven or fewer hours of sleep/night significantly increased the risk of obesity compared with >7 h sleep/night (80)	5877	10–19	45	Saudi Arabia
Less than 9 to 9.4 h sleep/night was associated with increased likelihood of obesity compared with ≥11 h sleep/night (111)	1311	3–4	50	China
Less than 6 h sleep/night and sleep fragmentation were both independently associated with higher BMI values (100)	612	18–50	58	U.S.
Short sleep duration was associated with increased weight status (112)	1108	5–13	50	U.S.
Compared with >11 h sleep/d, <9 h and 10–11 h sleep/d were associated with increased risk of obesity in a dose-dependent fashion (113)	7867	2–9	49	Europe
As total sleep time decreased, BMI increased (116)	1231	6–10	50	Sweden
Less than 6 h/night of time in bed was associated with increased BMI compared with 7–8 h/night of time in bed (107)	250	18–25	66	U.S.
Less than 6 h sleep/night was associated with increased BMI compared with 8–9 h sleep/night in adults in the sub-Arctic (108)	6413	30–65	52	Norway
Less than 7 h sleep/night was associated with increased BMI compared with 7–8 h sleep/night (124)	34,852	30–60	10	Japan
Influence of gender on sleep-weight status				
Inverse/males: short sleep duration was a significant predictor of overweight in males only (119)	4486	13–18	51	U.S.
Inverse /males: In males, <8–10 h sleep/night was associated with significant higher risk of obesity compared with ≥10 h sleep/night; no associations were observed in females (120)	6324	7–15	49	Australia
Inverse /males: a significant dose-dependent, inverse relation was observed between sleep duration and BMI in males but not in females (121)	4793	17–83	51	Hong Kong
Inverse /females: <8 h sleep/night was associated with higher values of BMI, total body fat, truncal fat, waist circumference, and hip circumference along with lower values of % LBM in females only (130)	500 twins	10–20	45	China
Inverse /females: significant inverse correlation between sleep and BMI was observed in women, whereas a negative trend was observed in men (126)	3473	33–45	54	U.S.
U-shaped/males: <5 h and ≥9 h sleep/night was associated with increased BMI gain over 1 y in males; no longitudinal association was observed in females (124)	34,852	30–60	10	Japan

(Continued)

TABLE 3 (*Continued*)

Key observations (reference)	*n*	Age range	Female	Region
U-shaped/females: Compared with 7 h sleep/night, ≤4 h and ≥9 h sleep/night was associated with increased likelihood of obesity in females only; no association observed among males (131)	23,579	14–18	51	U.S.
Inverse /males: an inverse relation between sleep and BMI was observed in males but not in females (122)	2006	26–28	52	U.S.
Inverse /males: as sleep duration decreased, BMI, waist circumference, and subcutaneous fat area increased in males only; no associations were observed in females (123)	6042	30–75	11	Japan
Longitudinal observations of associations between sleep and weight status				
Inverse: the highest increase in BMI over 8–10 y was associated with 2–4 h sleep/night whereas the smallest increase in BMI was associated with ≥10 h sleep/night (8–10 y study duration) (102)	3682	32–49	68	U.S.
Inverse: <7 h sleep/night was associated with significantly higher increases in weight over a 16-y period of time (~0.3–0.5 kg additional gain/y) (16-y study duration) (105)	68,183	39–65	100	U.S.
Inverse: irregular sleep habits at ages 2–4 y were associated with increased BMI at 21 y (21-y study duration) (117)	2494	0–1	50	Australia
Inverse: shorter sleep duration at 8 y of age was associated with overweight status at 11 y of age (3-y study duration) (110)	785	8	50	U.S.
U-shaped association: 5–6 and 9–10 h sleep/night were both associated with higher amounts of weight gain over 6 y compared with 7–8 h sleep/night (6-y study duration) (106)	276	21–64	53	Canada
Inverse: short-duration sleep at 5–11 y of age was associated with increased BMI at 32 y of age (32-y study duration) (118)	972	0–1	Not reported	New Zealand
Inverse: <12 h sleep/day was associated with increased BMI, skinfold thickness measures, and odds of overweight (3-y study duration) (133)	915	0–1	50	U.S.
No association: no longitudinal associations between sleep and BMI observed (15–20-y study duration) (100)	612	18–30	58	U.S.
Inverse for 0- to 4.9-y-olds: short sleep duration was associated with increased BMI 5 y later; no association for 5- to 13-y-olds (5-y study duration) (112)	1930	0–13	50	U.S.
U-shaped association for <40-y-olds: ≤5 and ≥8 h sleep/night was associated with elevated gains in adipose tissue and BMI over 6 y (6-y study duration) (134)	522	18–81	58	U.S.
No association: sleep duration earlier in life did not predict BMI 2 y later (2-y study duration) (114)	3045	0–1 and 4–5	49	Australia
Inverse: short-duration sleepers experienced greater increases in BMI and fat mass over 6 y compared with those sleeping 7–8 h/night; correction of short-duration sleep attenuated this change (6-y study duration) (84)	216	18–64	50	Canada
Influence of age on sleep-weight status				
Inverse for 11-y-olds; no association for 8-y-olds (3-y longitudinal study) (110)	785	Third- to sixth-graders	50	U.S.
Inverse for 6- to 7-y-olds; no association for 0- to 1-, 2- to 3-, or 4- to 5-y-olds (114)	3045	Birth–7	49	Australia
Inverse for 10- to 13-y-olds; no association for 14- to 17-y-olds (115)	723	10–16	52	U.S.
Inverse for 7- to 11-y-olds; no association for 32-y-olds (118)	1037	5–11 baseline, 32 at follow-up	48	New Zealand
Inverse for 32- to 49-y-olds; no association for 50- to 67-y-olds; no association for 68- to 86-y-olds (102)	9588 cross-sectional; 15,054 longitudinal	32–49 at baseline	68	U.S.

(Continued)

TABLE 3 (*Continued*)

Key observations (reference)	*n*	Age range	Female	Region
Associations between sleep and energy balance				
Inverse relation/intake: sleep <8 h/d associated with increased intake of high-fat and -sugar foods; no association: no associations between sleep and energy output or balance (152)	1976	5–10	50	Portugal
Inverse relation/intake: reduced quality of sleep associated with higher total fat intake (132)	300	10–17	49	U.S.
Inverse relation/intake: longer sleep associated with lower kcal intake (83)	41	2–5	58	U.S.
Positive association/PA: each hour of sleep disturbance decreased daily PA by 3% (78)	383	11–16	54	U.S.
Positive association/expenditure: <9 h/night of sleep associated with increased sedentary time; no association/PA: no association between sleep and moderate/vigorous PA (173)	519	7	51	New Zealand
Inverse relation/intake: short sleep duration and late timing of sleep were associated with increased consumption of calories and fast foods (155)	52	18–71	48	U.S.
No association/expenditure: no difference in RMR, TEE, PA, or diet-induced thermogenesis between 2 wk of 8.5 h sleep/night and 5.5 h sleep/night (68)	11	35–49	45	U.S.
Inverse relation/intake: <8 h/night of sleep was associated with increased kcal intake from fat and snacks (153)	240	16–19	52	U.S.
Inverse relation/intake: 1 night of sleep deprivation was associated with increased kcal intake; 1 night of sleep deprivation was not associated with hunger changes; inverse relation/PA: 1 night of sleep deprivation was associated with increased PA and activity energy expenditure (156)	12	19–25	0	France
Inverse association/intake and expenditure: 5 h sleep/night (vs. 9 h) for 5 nights was associated with increased TEE and kcal intake (158)	16	17–27	50	U.S.
Inverse relation/intake: 4 h sleep/night (vs. 7–9 h) for 4 nights was associated with increased fat and kcal intake; no association/expenditure: no differences in RMR and TEE were observed between conditions (157)	30 adults	30–49	50	U.S.
Inverse relation/intake: ≤6 h of sleep/night was associated with increased kcal intake from alcohol (84)	703	18–64	57	Quebec, Canada
Inverse relation/intake: shorter sleepers (≤6 h/night) had higher eating disinhibition and greater risk of overeating and weight gain (162)	276	21–64	58	Quebec, Canada
Inverse relation/ghrelin: <8 h sleep/night was associated with increased ghrelin concentrations; positive association/leptin: <8 h sleep/night was associated with decreased leptin concentrations (128)	1024	30–60	46	U.S.
No association/intake and PA: no differences in kcal intake or PA were observed with 4 h of sleep/night (vs. 8 and 12 h) for 6 nights; positive association/leptin: 4 h sleep/night was associated with reduced leptin concentrations (147)	11	18–27	0	Belgium
Inverse relation/hunger: 4 h sleep/night (vs. 10 h) for 2 d was associated with decreased leptin concentrations, increased ghrelin concentrations, and increased ratings of hunger; intake and PA were held constant (164)	12	20–24	0	U.S.
Inverse relation/intake and leptin: gradually decreasing sleep duration from 7 to 4 h of sleep/night (vs. >8 h) for 4 nights was associated with increased kcal intake, body weight, and concentrations of leptin and thyroid hormones; no association/expenditure: no differences were observed in RMR, PA, and TEE (165)	14	23–38	100	Germany

(*Continued*)

TABLE 3 (*Continued*)

Key observations (reference)	*n*	Age range	Female	Region
Inverse relation/leptin: 3 h sleep for 1 night elevated next-day leptin concentrations but did not affect hunger and craving scores; kcal intake was not measured (166)	15	18–25	100	Canada
Inverse relation/leptin: 1 night of total sleep deprivation increased leptin concentrations but did not affect hunger (167)	21	18–30	52	U.S.
Inverse relation/leptin: 4 h sleep/night for 5 nights was associated with increased leptin concentrations (168)	136	22–45	49	U.S.
Positive association/expenditure: 1 night of total sleep deprivation decreased RMR and diet-induced thermogenesis (170)	14	21–23	0	Germany
Positive association/PA: 4.25 h sleep/night (vs. 8.25 h) for 2 nights was associated with decreased PA and PA intensity; no association/intake: sleep restriction was not associated with changes in kcal intake, feelings of hunger, appetite, or ghrelin or leptin concentrations (171)	15	20–40	0	Germany
Positive association/ghrelin: 1 night of total sleep deprivation was associated with lower concentrations of ghrelin (172)	10	25–31	0	Germany
No association/PA: no relation between self-reported sleep duration and PA observed (105)	68,183 (NHANES)	39–65	100	U.S.
Positive association/PA: <7 h sleep/night was associated with not meeting vigorous PA requirements (174)	1203	20–92	76	U.S.
Positive association/RMR: 2 wk of a kcal-restricted diet plus 5.5 h sleep/night (vs. 8.5 h) was associated with reduced RMR; no association/TEE: sleep and kcal restriction were not associated with changes in leptin, ghrelin, or TEE (175)	10 overweight	35–49	30	U.S.
Inverse relation/PA: 2 nights of fragmented sleep was associated with increased PA and activity energy expenditure; no association/TEE and RMR: fragmented sleep not associated with changes in TEE or RMR (176)	15	20–27	0	U.S.
No association/RMR: 5 h sleep/night (vs. 10 h) for 7 nights was not associated with changes in RMR (5)	20	20–35	0	U.S.

[1] LBM, lean body mass; PA, physical activity; RMR, resting metabolic rate; TEE, total energy expenditure.

may help explain the contrasting findings in 32-y-old adults. Although the majority of evidence supports an inverse relation between sleep duration and weight status, some findings indicate that other factors beyond sleep duration may be important to consider.

Associations between quality of sleep and weight status also have been observed. Bawazeer et al. (80) reported that intermittent sleep, as opposed to continuous sleep, was associated with increased BMI in Saudi Arabian youth. Overweight and obese children were reported to have more disturbed sleep and altered sleep architecture as well as reduced sleep duration than normal-weight children (79,82,132). This same association was observed in adolescents (78) and college-aged subjects (77).

These cross-sectional findings collectively indicate a correlation between sleep and weight status throughout the life span, across cultures, and across genders. However, the specific effects of age, gender, and culture have not been fully elucidated.

Longitudinal observations. Longitudinal studies examining associations between sleep earlier in life and weight status later in life are highly varied (Table 3). Short sleep duration at age ≤4 y was strongly associated with risk of overweight 3–5 y later in 2 U.S. studies (112,133); however, no association was observed in Australian children ≤2 y of age in a 2-y prospective study (114). Two years may have been too little time to observe a longitudinal association in the latter study. In a long-term prospective study, longer sleep duration at the ages of 5–11 y was associated with a decreased risk of obesity at age 32 y (118). Similar conclusions were reported in women in a 16-y prospective study. Women who typically slept <5 h/night had an increased risk of weight gain (10–25 kg) over a 16-y period of time than those who typically slept 7 h/night (105).

Age may be another factor that explains the differences reported in longitudinal studies regarding the association between sleep and weight status. One study reported that an increased likelihood of being overweight in sixth grade was associated with short sleep duration in third grade (110). Conversely, another study reported that the sleep duration of 5- to 13-y-old children did not predict their weight status 5 y later (112). Hairston et al. (134) reported a U-shaped curvilinear relation between sleep duration and BMI 6 y later for Hispanic and African American subjects <40 y old and no association between sleep and later BMI for those subjects aged >40 y. This U-shaped curve indicates that younger adults getting too little or too much sleep are at greater risk of overweight status in the future than those sleeping a healthy length of time. Consistent with the findings of Hairston et al., no associations were found in middle-aged, predominantly Caucasian populations after 5–8 y of follow-up (100,102). More research is needed to delineate the effect of age on the longitudinal association of sleep duration and weight status.

One longitudinal study provided insight into the sleep-weight relation by observing 2 groups of adult short-duration sleepers over a period of 6 y (84). One group maintained their short-duration sleep habit, whereas the other group increased their sleep to a longer duration at some point during the 6 y. The subjects who maintained short sleep duration had greater increases in BMI and fat mass over the 6 following years than did subjects who increased their sleep duration to recommended levels (84). This noteworthy finding indicates that increasing sleep duration to suggested levels may attenuate long-term weight gain. However, more research is needed and the long-term consequences of altered sleep habits on weight status remain to be elucidated.

Experimental findings. Weight loss may be associated with sleep duration. For a group of obese adolescents, greater sleep duration at baseline predicted greater reductions in BMI after a 3-mo weight-loss intervention (135). One study reported positive changes in sleep duration in adults who lost weight consuming a very-low-energy diet for 2 mo (136). Conversely, another study did not find any associations between baseline sleep duration or changes in sleep duration and body weight changes in obese women (53 ± 11 y) after a 6-mo weight-loss intervention program (137). The effects of sleep on weight loss and vice versa remain to be fully understood.

Research regarding the effects of incorporating sleep into weight-loss interventions is in its infancy. Findings from a 12-wk pilot study indicated that the addition of a sleep management component to a weight-loss intervention program led to significantly more weight loss in 23 adult subjects (85). Two additional studies are currently in progress (138,139) and may provide more insight into the efficacy and effectiveness of including sleep management in weight-loss interventions. As part of a healthy lifestyle, encouraging adequate sleep is recommended regardless of its direct effects on weight loss.

Sleep and glucose metabolism

Studies examining the relation between sleep and glucose metabolism are rapidly accumulating and reveal that inadequate sleep may be a risk factor for type 2 diabetes (140–145). In a cross-sectional study, short sleep duration was related to insulin resistance in high school students (144). In fact, an overnight sleep study revealed that short duration of stage 3 and 4 NREM sleep was associated with insulin resistance even after controlling for BMI and Tanner score in adolescents (146). In clinical studies, decreased glucose tolerance in healthy adults was observed during waking hours after several nights of sleep reduction ranging from 4 to 5 h/night (4,147,148). The suppression of slow-wave sleep for 3 nights in 9 healthy adults led to reduced insulin sensitivity and glucose tolerance during the following waking hours despite the maintenance of total sleep duration and time spent in REM sleep (141). These findings indicate that sleep quality in terms of amount of time spent in slow-wave, deep sleep may be directly related to the circadian rhythm of glucose metabolism.

The depth of this topic expands beyond the breadth of this review, and other publications (149–151) should be consulted for further information regarding the effects of sleep on the risk of metabolic conditions. Nutrition professionals should be aware that health conditions associated with weight status, such as diabetes and cardiovascular disease, may also be influenced by sleep.

What Mechanisms Are behind the Sleep-Weight Associations?

It is well known that weight status is dependent on the combined effects of energy intake and energy expenditure. The complexities of overweight and obese status arise with the consideration of factors that affect these 2 sides of energy balance. This section reviews the studies examining the influence of sleep on both energy intake and energy expenditure.

Energy intake

Recent findings indicate changes in diet composition may be linked to sleep duration and energy intake (Table 3). In Portuguese children, reduced sleep duration was positively associated with intake of foods high in fat and sugar (152). Another study reported that reduced quality of sleep was associated with higher total fat intake in girls aged 10–17 y (132). Similar to children, short sleep duration in adults is associated with consumption of an increased percentage of daily calories from fat and snacks (153). Even alcohol consumption was significantly higher in adults sleeping <6 h/night than in those with longer sleep duration (154).

Observations of increased caloric intake with short sleep duration were reported in both children and adults. In obese preschool-aged children, increased sleep duration was associated with lower calorie consumption in a weight-loss intervention (83). More calories were consumed during the night by adults with short sleep duration than by adults with normal sleep duration (68,155). Several sleep reduction studies ranging from 1 to 14 nights of 4–5 h of sleep reported significantly increased caloric intake by participants (68,156–158).

These changes in diet composition may be related to disinhibited eating behavior. This behavior is characterized by responding to various external stimuli, such as stressful situations or an abundance of appetizing foods, with an inclination to overeat (159). Not only has daytime sleepiness been associated with reduced inhibitory control with regard to high-fat and high-calorie foods (160) but specific regions of the brain were highly activated in response to unhealthy food stimuli after 5 nights of partial sleep deprivation compared with normal sleep duration in healthy adults (161). A longitudinal study in 276 adults revealed that short sleep duration compared with average or long sleep duration increased the risk of weight gain and increased waist circumference over 6 y; however, further analysis revealed that short-sleeping participants with a "high disinhibition eating behavior trait" had a significantly higher risk of weight gain compared with those with a "low disinhibition eating behavior trait" (162). Changes in eating behavior may be caused and/or exacerbated by short sleep duration. On the other hand, increasing nightly sleep duration from 6.5 to 8.5 h/night for 2 wk led to significant decreases in overall appetite and desire for salty and sweet foods in 10 overweight adults (163).

The effect of sleep duration on energy-related physiologic controls also has been examined. Concentrations of leptin and ghrelin, hormones related to appetite control and energy balance, are altered with short sleep duration (99). Leptin inhibits appetite through several actions in the hypothalamus. Some studies reported a reduction (128,147,164), whereas others reported an increase (165–168) in leptin concentrations with partial or total sleep deprivation. Other studies did not find any differences in leptin concentrations, but reported increases in concentrations of ghrelin after partial sleep deprivation (169,170). Ghrelin enhances feelings of hunger. Elevated concentrations of ghrelin may help explain changes in eating habits associated with short sleep duration. Much like leptin, the findings regarding the effects of partial or total sleep deprivation on ghrelin concentrations are mixed [not altered in some studies (68,165,171) and lower in others (172)], likely due to variations in study populations, study design, sleep duration, and other factors. Despite these differences, findings suggest that alterations observed in these hormones occurring with reductions in sleep duration are associated with increased calorie intake and weight status.

Energy expenditure

Less research has examined the effects of sleep duration on energy expenditure (Table 3). Observational studies examining the relation between sleep duration and physical activity in children suggest that short sleep duration leads to an increase in sedentary activities (78,173). Observations in adults are not as consistent. A large cohort study found no relation between self-reported sleep duration and amount of physical activity in women (105), whereas another larger study found that short sleep duration was associated with reduced vigorous activity levels in adults (174). Two different experimental studies revealed that 1 night of sleep restriction (4 h) altered adults' physical activity levels the following day by either increasing energy expended in physical activity (156) or by decreasing the energy expended from physical activity through a reduction in intensity (171). In addition to the multiple, well-known factors affecting physical activity levels, sleep is worthy of consideration. Future research should consider physical fitness as a confounding factor of the relation between sleep duration and physical activity levels.

Sleep restriction studies focusing on energy expenditure, as opposed to physical activity level, also revealed disparate findings. Whereas some studies reported a decrease in resting metabolic rate (RMR) with sleep reduction (170,175), other studies reported no change in RMR (5,68,157,165,176). Although RMR is a very important factor affecting weight status, total energy expenditure (TEE) may be a more insightful measure. A majority of the studies examining the relation between sleep restriction and energy expenditure reported no effects on TEE (68,157,165,175,176), indicating that reduced energy expenditure may not be a major contributor to the association between short sleep duration and increased weight status. Small sample size, short trial duration of ≤14 nights, variation in sleep and estimation of energy expenditure protocols, among other limitations, prevent conclusive statements at this time, but sleep duration may affect different components of TEE in a compensatory manner. For example, an increase in sleep energy expenditure may be paired with a decrease in activity energy expenditure. More research is needed to examine the effects of sleep duration on the components of TEE and on different subject populations.

Sleep and Health Promotion: Nutrition Communication and Counseling

Clearly, sleep is fundamental to health and well-being. Sleep also is highly associated with weight status and dietary intake. Thus, it is prudent for nutrition professionals to promote good sleep hygiene, particularly as a component of healthy lifestyles and weight management. Sleep hygiene refers to the behaviors and practices that enhance sleep duration and quality, such as preparing for sleep, engaging in physical activity, and practicing relaxation techniques. Sleep hygiene education effectively enhances sleep quality and decreases daytime sleepiness in healthy working adults (177,178) and children (179,180).

It is also imperative for nutrition professionals to recognize that the will to intentionally reduce sleep duration is a possible behavioral issue that may be related to social influences. These social influences can be as obvious as the pressure to complete more work each day or the drive to spend more time with family. However, these influences can be less transparent, such as waking very early to avoid morning traffic without compensating with an earlier bedtime. As always, the environmental, behavioral, and social aspects of any nutrition-related issue should be considered within the nutrition care process.

To remain within the professional scope of practice while serving clients and patients, nutrition professionals should determine when referral to a sleep specialist is needed. Patients and/or clients describing symptoms that align with a sleep disorder (see Table 2) should be referred to a sleep specialist. Additionally, individuals engaging in improved sleep hygiene and sleep preparation practices without experiencing positive effects within a reasonable time also need referral. Credible sources for locating referral services include the NSF Web site (28) and American Association of Sleep Medicine–accredited sleep centers. The nutrition professional should use skilled judgment and make referrals as necessary.

Including sleep in the nutrition assessment

An informal screening process can be efficiently incorporated into all nutrition assessments. Table 4 provides sample questions that can be included in screening, assessment, and/or monitoring sessions along with desired answers. When the desired answers are not received, further assessment with the user-friendly Pittsburgh Sleep Quality Index (181,182), Epworth Sleepiness Scale (183), or Berlin Questionnaire (184) can be conducted. Individuals should be referred if any of these screens indicates poor sleep and/or individuals describe symptoms aligning with a sleep disorder, including shift work and jet lag.

Promoting healthy sleep with sleep hygiene

Evaluating the lifestyle factors associated with inadequate sleep is a good starting point for nutrition professionals to promote better sleep. This section reviews the general practices and supporting evidence of healthy sleep promotion.

Preparing for sleep. Bedtime routines help prepare the body and mind for sleep. Guiding patients or clients through the development of relaxing bedtime routines that include elimination of or reduction in caffeinated foods and beverages, dim lights, calming activities, setting a regular bedtime and wake time (if a consistent bedtime is not possible, then only going to bed when sleepy), and creating a comfortable, dark, quiet sleep environment that has minimal noise and/or soothing sounds promotes restful sleep (179,180,185). Table 5 provides an overview of recommendations for improving sleep.

Engaging in physical activity and exercise. Several studies have examined the effect of physical activity and exercise on sleep. A positive relation between sleep quality and duration of intense physical activity was observed in a large cross-sectional study observing >1200 children aged 6–10 y (116). In this study, moderate-to-vigorous physical activity, as measured by accelerometers, enhanced sleep quality even though total sleep time was not affected (116). Another study evaluated the effects of aerobic exercise on snoring in overweight 7–11 y olds (59). Snoring is a symptom of sleep-disordered breathing and can lead to arousal from sleep. After 13 ± 1.5 wk of intervention, children who engaged in either a 20- or a 40-min duration of vigorous activity every day after school experienced an improvement in snoring compared with the children who did not engage in vigorous activity (59).

The majority of studies examining the effects of exercise on sleep quality are conducted in adults with sleep complaints. Walking programs were effective in improving sleep quality in women with breast cancer (62) and women with diastolic heart failure (60). Tai chi also appears to improve sleep quality in healthy older adults. In comparison with health education, 16 wk of Tai Chi Chih (a type of tai chi) education and practice dramatically improved sleep quality in older adults with previous moderate sleep complaints (61). Both tai chi and seated exercises practiced regularly for 24 wk increased sleep duration and improved sleep quality in older adults with previous sleep complaints (58). A systematic review of 6 separate trials revealed a positive effect of both aerobic and resistance exercise of various durations and moderate-to-high intensities on sleep in middle-aged and older adults (186).

The positive effects of exercise on sleep are well supported in the literature. Endorsing physical activity and regular exercise as part of a healthy lifestyle is highly encouraged. Nutrition professionals should feel comfortable recommending walking activities to sedentary individuals. The Physical Activity Readiness Questionnaire (187), should be completed before other exercise recommendations to determine if consultation with a physician is necessary. With all exercise regimens, patients and clients should be encouraged to listen to their bodies to decipher discomfort from pain. Additionally, information on proper form and technique of specific exercises should be provided.

Massage therapy. Massage is a form of body work involving the mechanical manipulation of dermal, myofascial, connective, and musculoskeletal tissue. The therapeutic effects of massage are widely documented, and several studies have examined the effect of massage on measures of sleep. In pregnant (188) and postpartum (189) women, massage on a regular basis improved sleep quality. As little as 3 min of slow-stroke back massage performed on nursing home patients increased sleep duration by an average of 46 min/night (190). A literature review examining different nursing interventions used to promote sleep found that massage was more effective than sleep hygiene and relaxation techniques in improving sleep quality of patients (191). In a randomized controlled trial, massage therapy was effective at reducing daytime fatigue and improving sleep quality in coronary artery bypass patients (192).

Many people may believe that financial limitations are a barrier to regular massage therapy. Similar to exercise, including massage as a lifestyle behavior does not need to be limited to advanced methods provided by experts. Trusted friends and family members can perform basic massage.

TABLE 4 Sample questions and desired answers to include in nutrition assessment

Sample questions	Desired answers
1. What time do you go to bed every night and wake up every morning?	Consistent (even on weekends)
2. How many hours do you sleep on an average night?	7–9 h of actual sleep
3. Do you have difficulty falling asleep once in bed?	No, usually fall asleep within 30 min
4. How many times do you wake each night?	Rarely, wake once per night
5. Do you feel refreshed upon waking in the morning?	Yes, no feelings of grogginess or grogginess dissipates within a few minutes
6. How often do you feel sleepy during the day?	Rarely

TABLE 5 General recommendations for improving sleep

Lifestyle factor	Explanation	Recommendations
Timing of sleep	Consistent timing of sleep enhances the maintenance of circadian rhythms	Keep consistent bedtimes every night and consistent wake times every morning
Physical activity and exercise	Regular physical activity or exercise is associated with improved sleep quality	Engage in physical activity and exercise on a regular basis
Caffeine consumption	Even low amounts may affect sleep	Reduce or eliminate caffeine-containing beverages and food consumption, especially after lunchtime
Cigarette smoking	Voluntary and involuntary arousal	Teach effects of smoking on sleep; encourage cessation
Media use	Emotion-evoking media that stimulates an individual before bedtime	Move engaging television programs, addictive games, and intense videos or music to earlier in the day; discourage children from viewing violent content
Bright lights during dark hours	Bright lights may attenuate physiologic preparation for sleep	Dim or reduce overhead lights; consider using low-wattage nightlights; lower screen brightness levels on media displays when used at night; turn off electronic displays 1–2 h before bedtime
Relaxing activities	Stress and arousal reduction	Hot bath, soothing beverages, meditation, massage, deep breathing, reading soothing content
Comfortable environment	Enhances readiness to sleep	Noise reduction, comfortable temperature and bedding, dim lights, apply pleasant scents such as lavender or chamomile

Additionally, affordable electronic massage instruments are widely available and may have similar effects. Once again, patients and clients should be encouraged to listen to their bodies and engage only in massage that does not induce pain.

Daytime napping. Polyphasic sleep (multiple sleep sessions throughout the day) is common in many animals and in humans during infancy. As infants develop into preschool-aged children, sleep session frequency changes from polyphasic to biphasic in which 2 sleep sessions are completed in a 24-h period. Daytime napping is a common practice for preschool-aged children. Recent research has revealed that these daytime naps enhance cognitive memory in preschool-aged children, lending possible enhancements to learning performance (193). Around the age of 5 y, the monophasic sleep pattern is adopted in which the daytime nap is eliminated and all sleep occurs during the night (194). This monophasic sleep pattern is commonly maintained for the remainder of the life span.

A 2013 NSF survey reported that 51% of the U.S. adults surveyed engaged in at least 1 nap over a 2-wk period of time (25). Similar results were reported for other countries included in this survey (25). Daytime naps are encouraged for those with short nighttime sleep duration, older adults, and patients with sleep disorders (195). The benefits of daytime napping include increased cognitive performance, feelings of invigoration, and increased late-day alertness (196). In fact, daytime naps were more effective at reducing daytime sleepiness than either extended morning sleep or increased coffee consumption in young adults who did not receive sufficient nighttime sleep (197).

The optimal duration of daytime naps for healthy adults appears to be between 10 and 30 min (195,196). The elderly and individuals who engage in shift work may benefit from longer naps, ranging from 40 min to >2 h (73,198–200). Experts suggest that afternoon is an ideal time to nap because of the natural inclination to feel tired around this time (196). The "midday" point will differ for shift workers and their nap should be taken at a time that is halfway between their waking hours (199).

The notion that daytime naps will reduce subsequent nighttime sleep is not well supported by the literature. In fact, the duration of nighttime sleep did not significantly differ between nap and non-nap conditions in elderly (201) and young adult (197,202) populations. A drawback of daytime napping is sleep inertia, which is the impaired cognitive functioning and alertness that occurs for a short period after waking (196). A notable study examining sleep inertia and cognitive function after 90-min naps reported that the ability to perform simple tasks returned to the non-nap performance level much more quickly than the return of the ability to perform executive functions (202). The duration of the nap should be controlled to reduce the effects of sleep inertia (196). The effects of naps should be considered in nutrition practice and research.

Conclusions

Knowledge of human physiology and healthy lifestyle behaviors is rudimentary to nutrition practice. Inadequate sleep is a detriment to physical and mental health and may lead to long-term consequences if left untreated. An inverse relation is the most common finding among numerous studies examining sleep duration and weight status. Research examining the effects of sleep on energy balance needs to be continued to provide the field with a better understanding of the link between sleep and weight management. Mounting evidence has linked sleep to metabolic conditions such as cardiovascular disease and diabetes.

Insufficient and/or poor-quality sleep is prevalent in our culture. The plethora of evidence surrounding the link between sleep and health confirms the need to address sleep in health promotion, nutrition communication, and in weight-related research efforts. Sleep, like stress management and activity level, is a lifestyle factor that should be assessed and monitored by nutrition professionals and researchers.

By addressing sleep assessments and sleep hygiene, nutrition professionals have the potential to reveal sleep inadequacies, promote sleep hygiene, and, when indicated, refer individuals to sleep specialists, all of which may lead to great strides in an individual's progress toward achieving a healthy lifestyle.

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