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Effect of Food Intake on Sleep: Mechanisms and Recommendations

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ABSTRACT

Sleep is a crucial lifestyle component that improves general health. The effect of diet and consumption of certain foods has been reported to have a significant effect on sleep patterns and sleep quality. Many supplements were used to help promote healthy sleep. However, the connection between some food factors and sleep is rather complicated. The nutritional components change depending on the food habits and the digestive and metabolic processes of each person. Several studies and systematic reviews reported potential benefit of specific nutrients and their role in sleep including: high-fiber and low-sugar carbohydrates, protein, fatty acids, several vitamins such as vitamins D, C, and B and electrolyte especially magnesium. Others were reported could disrupted sleep such as caffeine, alcohol and excess sugar. This article discussed nutrients that are potential to play a role in sleep quality, their mechanisms, and food recommendation that can be made to help improve sleep quality and sleep wellness.

Keywords: Diet, sleep-promoting food, sleep quality

INTRODUCTION

Sleep is an essential biological function for health and happiness throughout life. Good quality sleep is associated with a host of advantages, including improved immunity, improved cardio-metabolic health, and improved cognitive function, mood, and mental performance.[1] Contrarily, poor sleep quality, both in terms of insufficient sleep time and in terms of sleep quality, is detrimental to health, increasing the risk of metabolic syndrome and cancer in people of all ages through behavioral issues.[2]

Sleep quality has been linked to a variety of factors that can affect health and provide cognitive benefits. Sleep plays a role in aspects of cognition including declarative memory, recall memory, and cognitive flexibility.[3] In addition to these cognitive domains, sleep duration also influences levels of daytime alertness, subjective alertness, and even the capacity to regulate emotions.[4,5] A study reports sleep deprivation can cause an increase in amygdala activity by up to 60% and increase pupil diameter, these can increase a person's emotional reactivity to negative information. [6]

These benefits of sleep on health are the reason for the importance of interventions to improve life satisfaction and psychological health. Among the many variables that can be changed, dietary habits and consumption are believed to have an impact on changes in the metabolic control of hormone release, which affects the characteristics and quality of sleep.[7] Additionally, it has been suggested that sleep length and quality influence the risk of obesity, diabetes, hypertension, and cardiovascular disease.[8]

It is complicated to comprehend how nutrition affects sleep regulation. and can be explained in several ways. First, the components of diet can directly influence

sleep. For example, caffeine in coffee and tea has components that work antagonists against sleep-inducing adenosine receptors (A2AR) so that they can play a direct role in causing a decrease in sleep time and quality and increasing sleep induction time.[9] Second, numerous dietary metabolites can become bioactive and affect sleep regulation directly or indirectly by influencing other variables that are connected to sleep. Be aware that nutrition has a substantial impact on the commensal microbiota, which may have an impact on how metabolites are formed and are metabolized.[10] Third, nutritional factors over a long period of time can change the inflammatory condition, which is closely associated to sleeplessness. However, there are still many unanswered, difficult concerns about the processes of inflammation in sleep.[11]

It is important to know the types of food and dietary patterns that can that relate to sleep and the quality of sleep. This article will discuss the type of foods that have potential to affect sleep, their mechanisms, and dietary recommendation in selecting types of food for nutritional counseling as non-pharmacological therapy of sleep disorders.

DIET AND SLEEP QUALITY

In contrast with sleep duration which can be clearly defined, sleep quality has a broader meaning. During a polysomnography exam, the amount of slow wave sleep (SWS) and rapid eye movement (REM) can be measured to determine the quality of the sleep. Sleep efficiency (SE), which is the time spent in bed sleeping, and sleep-onset latency (SOL), which is the length of time it takes for a person to fall asleep, can both be used to measure the quality of a person's sleep during polysomnography and actigraphy tests. A lackluster night's sleep is often characterized by low SE (85%) and a long SOL (>20–30 minutes). A subjective sleep quality test, such as the Pittsburgh Sleep Quality Index, can be used to measure sleep quality (PSQI).[7]

Several epidemiological studies have reported a relationship between sleep quality and dietary patterns. A cross-sectional study with a sample of working women in Japan reported that consumption of sweets and noodles was associated with poor sleep quality, as evidenced by the PSQI questionnaire. Meanwhile, high consumption of fish and vegetables is associated with good sleep quality. The quality of the carbohydrates consumed is also more important than the quantity. Samples with poor sleep quality tended to consume high carbohydrates from sweets and noodles rather than rice compared to samples with good sleep quality, even with the same high carbohydrate intake. Consumption of energy drinks or sugar-sweetened drinks more than once per month is also reported to be associated with poor sleep quality.[12] In contrast to high protein consumption (>19% of energy from protein), which is linked to trouble maintaining sleep, some research have found that low protein consumption (16% of energy from protein) is linked to both poor sleep quality and difficulty keeping sleep. Sleep quality is negatively correlated with low carbohydrate intake (50% of energy from carbs). After excluding the effects of gender, this association was substantial for men but not for women.[13] This finding is also supported by other studies reporting low protein consumption associated with sleep disturbances (Obstructive sleep apnea, insomnia, or a combination of the two) where individuals with these sleep disorders reported lower protein consumption and higher fat consumption compared to individuals without sleep disorders.[14]

Studies on the epidemiology have shown a connection between dietary habits and sound sleep. These studies demonstrate that high-fat consumption is connected with poorer sleep quality. Carbohydrate consumption can also affect sleep quality where low carbohydrate consumption is associated with insomnia symptoms but high consumption of high-sugar carbohydrates is also associated with insomnia. It is predicted that the type and quality of carbohydrates are important in the

relationship between sleep quality and diet. The role of nutrition, not only carbohydrates, protein, and fat, but also other nutrients in sleep disorders is important to know and discuss further.

NUTRITION AND SLEEP DISORDERS

Carbohydrate

The dietary glycemic index, which is based on the impact of postprandial blood sugar, has been increasingly frequently employed as an indication in studies analyzing sleep disruptions caused by carbs. It has been suggested that a high glycemic index is linked to cancer, stroke, and other chronic disorders. Consuming foods with a high glycemic index causes blood sugar to rise quickly, which triggers an increase in insulin as a form of compensation as well as various humoral effects.[15]

Contradictory findings emerged from studies on the contribution of carbs on sleep disorders. When healthy people consume carbs with a high glycemic index four hours before bed, their SOL is significantly reduced (by 48.6%), as opposed to those who consume foods with a low glycemic index.[16] However, a high glycemic index diet was found to increase the risk of sleeplessness in another study. In three years, an increased prevalence of sleeplessness has been linked to a high glycemic index diet, according to research. Additionally, it has been shown that dietary patterns with a high intake of sugar, starch, and unprocessed grains are linked to a higher prevalence of insomnia. This study also revealed that non-processed fruit and foods with greater fiber contents were linked to lower prevalence and incidence of insomnia.[12] Supporting these findings, a study evaluating a 48-hour very low-carbohydrate diet compared with a controlled mixed diet reported increased SWS and decreased REM presentation.[17]

The ratio of tryptophan to other important Large Neutal Amino Acids (LNAAs), such as tyrosine, phenylalanine, leucine, isoleucine, valine, and methionine in circulation, can be impacted by foods having a high glycemic index. A greater ratio of tryptophan to LNAA is the result of insulin increasing the muscle's ability to selectively absorb LNAs. Changes in this ratio can lead to an increase in tryptophan in the brain because tryptophan and LNAA compete for delivery to the brain. Sleep is induced by the serotonin precursor tryptophan. Serotonin levels in the brain can rise after consuming carbs. [15] The creation of melatonin, which is controlled by darkness, is not always connected to the rise in serotonin. Instead, they propose that a high glycemic index diet's induction of hyperglycemia and the compensatory hyperinsulinemia that results from this can cause the release of autonomic counterregulatory hormones such as adrenaline, cortisol, glucagon, and growth hormone that cause sleeplessness.[18] High glycemic index meals have also been demonstrated to trigger an inflammatory immunological response and to cause the turnover of the gut flora, both of which may influence the quality of sleep. [10]

The role of carbohydrates in sleep quality was still reported to have variety results. The form and quality of carbohydrates, as well as the time of consumption are thought to be important factors affecting sleep quality. Studies conducted in different populations with different sample sizes and study designs can play a role in this variation. However, more studies are needed to explain the relationship between high carbohydrate diets and insomnia from a mechanism perspective.

Fatty Acids

Fatty acids are one of the main nutritional components, including saturated and unsaturated fats. Low Density Lipoprotein cholesterol (LDL-C) levels can rise as a result of high saturated fat intake, which is also linked to a higher risk of diabetes and cardiovascular disease. Numerous studies have been conducted on the effects of unsaturated fats on health, particularly those involving the omega-3 polyunsaturated fatty acids (PUFA), eicosapentaenoic acid (EPA),

and docosahexaenoic acid (DHA).[15] Consuming omega-3 PUFA is said to reduce the risk of cardiovascular disease and stroke, in contrast to saturated fat.

Studies of saturated fatty acid role in sleep quality were still limited. According to a study done on healthy-weight people, eating a lot of saturated fat causes SWS to last less time and cause more overnight awakenings.[19] Another study found a negative connection between the ingestion of saturated fat and total sleep time as determined by actigraphy.[20] From this limited study, it can be estimated that consumption of saturated fat can worsen sleep quality and health.

Omega-3 PUFA is a type of unsaturated fat that is known to have benefit for health because it is reported to be an anti-inflammatory agent and prevent cardiovascular disease and stroke. This nutrient can be found in fish and vegetables. Studies show diets deficient in omega-3 PUFAs disrupt night's sleep by affecting the rhythm of melatonin production and circadian rhythm function.[21] Other findings shown that the composition of omega-3 in gluteal adipose tissue is positively correlated with sleep health including SWS and REM among obese patients with obstructive sleep apnea (OSA).[22] Another study found that eating salmon three times per week improved EPA+DHA levels, resting heart rate variability, and general sleep quality. [23]

Amino Acids

Amino acids are essential nutrients that function as a building block for protein. There are many types of natural amino acids that can be found in the human diet. The amino acids that have been studied for their role in sleep are tryptophan, gamma-aminobutyric acid (GABA) and tyrosine. Serotonin substrate tryptophan has been evaluated for its involvement in sleep. Although its role is still under debate, serotonin is known to be a major sleep mediator and promotes wakefulness and Non-REM sleep.[24] A study in Japan reported the consumption of tryptopan at breakfast is needed to maintain morning diurnal rhythm and good sleep quality. This study assessed tryptophan levels from food by calculating the tryptophan index in the consumed foods.[25]

GABA is a bioactive amino acid that does not form a protein Glutamate decarboxylase catalyzes the decarboxylation of L-glutamate, which produces GABA. Foods that have undergone fermentation by lactic acid bacteria or yeast typically have higher GABA concentrations. Several studies report the role of GABA as a sleep promoter. A study on 40 insomnia patients reported reduced sleep latency and improved sleep quality after receiving GABA supplements (300 mg/day).[26]

Tyrosine is a non-essential amino acid, with norepinephrine metabolites. Norepinephrine is known as a neurotransmitter that plays a role in the fight-or-flight response and awareness. Norepinephrine levels are lowest during sleep and increase when awake. The precursor to norepinephrine dopamine also inhibits adrenergic receptor signaling and blocks melatonin synthesis via α1B-D4 and β1-D4 receptor heteromers.[27] However, although in theory tyrosine may play a role in sleep, research on this topic has not been extensively conducted.

Vitamin

Some vitamins are thought to play a role in sleep, including vitamin D, vitamin C and vitamin B. The most important forms of vitamin D are vitamins D3 and D2 which the body synthesizes from sunlight and can be obtained from food. One of the main sources of this vitamin is fish fat. According to a meta-analysis, vitamin D insufficiency has been linked to an increase in sleep disruptions such as poor sleep quality, short sleep duration, and daytime drowsiness.[28] The correlation between serum vitamin D levels and the prevalence of OSA was revealed in a different investigation. This is believed to be connected to oxidative stress and inflammation.[29]

Vitamin C, which is found in citrus fruits and vegetables, is reported to have protective properties in the brain to fight memory problems and sleep difficulties. One study reported that people with short sleep duration consumed less vitamin C than people who had normal sleep duration.[30] However, the connection between vitamin C and sleep problems has not yet been properly analyzed in the literature.

Vitamin B is thought to substantially affect the quality of sleep. Vitamin B12 is reported to be able to increase plasma melatonin concentrations that are related to improving sleep quality. Additionally, vitamin B-6 performs a cofactor role in the production of serotonin from 5-hydroxytryptophan, which indirectly influences the production of melatonin. However, 100 mg of vitamin B-6 supplementation had no impact on melatonin secretion or the length or quality of sleep. [7]

Electrolyte

Several electrolytes are reported to play a role in the quality of sleep. The CARDIA (Coronary Artery Risk Development in Young Adults) study reported that magnesium supplementation was associated with improved sleep duration and quality (OR= 1.23; 95% CI= 0.999).[31] Another study on primary insomnia in the elderly found that supplementing with 500 mg of magnesium for 8 weeks resulted in statistically significant increases in sleep duration and efficiency, as well as a decrease in the Insomnia Severity Index (ISI) scale, sleep onset latency, and serum cortisol levels. This is corroborated by a meta-analysis of research on the use of magnesium supplements in elderly people, which had comparable outcomes. [32,33]

The influence of calcium on sleep has also been investigated. A study conducted on shift workers found a link between low calcium levels and daytime dysfunction, sleep latency, and total sleep time.[34] According to recent studies, calcium is essential for producing slow oscillations during NREM sleep.[35] Low calcium levels may make it difficult for slow wave activity to be produced, necessitating longer sleep cycles to relieve the pressure associated with them during the wake phase. It is possible to assume that a low calcium level decreases slow-wave activity and lengthens total sleep time in order to preserve the homeostasis of slow-wave energy, which is the cumulative sum of slow-wave activity across total sleep duration.[34] The consumption of dairy products, which are high in tryptophan and calcium, has also been linked to reported improvements in sleep quality. Calcium facilitates the brain's use of tryptophan in the production of melatonin, enhancing sleep quality.[36]

FOOD AND DIET RECOMMENDATIONS

Several food choices can be recommended to improve sleep quality and are called sleep-promoting foods. Some foods, such as milk, fatty fish, and fruits such as cherries and kiwis, have been studied for their potential benefits for improving sleep quality without major dietary changes.

Milk

Consuming milk before bedtime is thought to improve sleep quality. A study on middle-aged adults with insomnia found that melatonin-rich milk improved sleep quality and decreased the number of awakenings.[7] Milk, which is high in tryptophan and melatonin, has a sedative effect and speeds up the onset and duration of sleep in mice. Mice under study had balance and motor coordination impairments equal to those caused by nighttime milk feeding.[37]

Malted milk and sleep-related nutrients have only been the subject of brief interventions and small population investigations in clinical trial trials. Malted milk may improve the quality of sleep, according to recent findings, albeit the mechanism remains unknown. Malted milk drinking before night may or may not enhance the quality of your sleep depending on the time of day you consume it. This needs further

confirmation. Malted milk has many important ingredients such as wheat, malt, sugar, milk, vitamins and minerals such as vitamins D and B. These nutrients are thought to improve sleep quality through the mechanisms previously described. Milk also has high levels of tryptophan and melatonin which are beneficial for sleep.[7]

Fish and Fish oil

Fatty fish with a fat content over 5% is an excellent source of omega-3 fatty acids and vitamin D. These nutrients have a crucial role in controlling serotonin, which in turn controls sleep. A study examining the impact of consuming fatty fish on sleep was reported by Hensen et al. In comparison to the control group, which received the same quantity of protein, the group that had 300g of Atlantic salmon three times a week for six months showed greater levels of vitamin D and fatty acids (EPA and DHA) (chicken, pork or beef). According to reports, the control group's sleep onset latency and wake times were longer than those of the intervention group.[23] Vitamin D was also discovered to have a positive correlation with both sleep efficiency and sleep quality, supporting these findings.[38]

Fruits and Vegetables

Kiwi and cherries are two fruits that have been suggested to affect sleep. For four weeks, eating two kiwis an hour before bedtime dramatically increased the amount of time spent sleeping and the quality of that sleep, as determined by actigraphy. Additionally, compared to baseline, the sleep diary revealed a reduction in wake after sleep onset (WASO).[39] Another study evaluated consumption of 200g cherries with 7 different cultivars (Jerte Valley Cherry) at lunch and dinner during a 3 day and 1 week washout period between different types of cherries. Following consumption of each variety of cherry cultivar, there was an increase in urine melatonin, antioxidant capacity, and overall sleep duration. Although there are variations in the results for each cherry consumed. This finding is in line with high levels of melatonin and tryptophan in types of cherries.[40] Even so, this report still needs further research, especially whether other types of cherries can also have high melatonin and tryptophan levels and can play a role in sleep quality. Apart from that, according to reports that magnesium deficiency can interfere with the time and quality of sleep eating vegetables, particularly leafy greens like kale and spinach, which are high in magnesium, need to be added to the variety of daily foods.[33] Date palm fruits were also reported to have high antioxidants and melatonin. In dates, melatonin concentrations ranged from 2 to 16 ng/100 g fresh weight, however the melatonin isomer was discovered to have concentrations up to 1,000 times higher.[41] This findings could lead to potential role of date palm fruits in sleep. However, this potential correlation needs to be studied further.

THINGS AND FOODS TO AVOID

Apart from the recommended foods, there are other foods and things that need attention to avoid, including consumption of coffee and cigarettes. Caffeine promotes alertness by acting as an antagonist of adenosine receptors. Thus, coffee consumption can also lead to a reduced desire to sleep. In addition, consuming modest amounts of caffeine each day might affect the duration, onset and quality of sleep and increase daytime sleepiness.[8] Regular usage of caffeinated energy drinks reduced sleep duration, sleep quality, and increased likelihood of dozing off during guard duty and briefings, as reported in a 2010 CDC report on military troops in combat environments.[42]

Poor sleep duration and quality are also linked to active and passive smoking. According to a study conducted on preschool-aged children in Hong Kong, breathing in secondhand smoke at home increases the likelihood of snoring.[43] Smoking is linked to decreased sleep duration, higher sleep latency, fragmented

sleep (several awakenings throughout a sleep session), and disrupted sleep architecture in adults.[44]

CONCLUSION

Nutrition and dietary patterns play a role in sleep quality. Selection of food ingredients with carbohydrates, low in sugar and rich in fiber, protein, fatty acids and sufficient vitamins can help improve sleep quality. Food choices such as fruit and vegetables, whole grains, and fish oil or vegetable oil (low in saturated fat) can be an option.

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