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Plant-based diets: Reducing cardiovascular risk by improving sleep quality?

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Abstract

Purpose of review—The goal of this review is to evaluate recent research related to the effects of plant-based diets on sleep patterns. We discuss plausible mechanisms for the link between plant-based diets and sleep, and provide suggestions for future research in this area.

Recent findings—Short sleep duration and poor sleep quality have been shown to negatively affect individual dietary habits, through enhanced appetite, increased overall caloric intake, as well as lower diet quality. Emerging data also indicate a novel bi-directional association by which dietary choices may also influence sleep duration and quality, but little is known about dietary patterns and their influence on sleep. Epidemiological studies report associations between Mediterranean diet eating patterns and sleep quality, suggesting a benefit of plant-rich diet consumption on sleep. The high isoflavone and tryptophan content of these diets may be a mechanism by which plant foods may enhance sleep quality.

Summary—Plant-based diets may provide additional benefits to health via their potential effects on sleep quality. Research is needed to establish a causal relation between a plant-rich dietary pattern and sleep health.

Keywords

Mediterranean diet; plant-based diet; sleep; tryptophan; cardiovascular disease risk

Introduction

Sleep duration has been show to influence dietary intakes. In several intervention studies, reducing sleep has been shown to increase caloric intakes in addition to altering dietary

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Conflict of Interest

Allison Crawford declares no conflicts of interest.

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quality. [1–5] It has been reported that sleep restriction increases energy intakes from snacks, [2, 1] fat, [5, 3] and carbohydrates. [1] Using data from the Women's Health Initiative, Grandner et al. [6] also noted associations between dietary fat intakes and total sleep time (inverse) and napping (positive). However, directionality of these associations and causality cannot be established from such epidemiological findings. Nonetheless, there is general agreement that sleep duration impacts dietary intakes. [7]

More recently, we have provided evidence that diet may also influence sleep. In a sleep intervention study, we assessed sleep quality under periods of controlled and *ad libitum* feeding when participants were permitted a 9-h sleep opportunity. After a single day of *ad libitum* feeding, when energy intakes were approximately 25% higher, and saturated fat were 33% higher than during the controlled feeding portion of the study, participants took 12 min longer to fall asleep, and slow wave sleep was reduced by 5 min. [8] When we assessed the relation between diet and sleep, we noted a significant positive relation between fiber intakes and time spent in slow wave sleep, but an inverse relation between saturated fat and slow wave sleep. Sugar intakes were related to significantly higher number of arousals at night. Our results suggested that dietary patterns with higher complex carbohydrates and lower saturated fat content, such as plant-based diets, could have potential benefits for sleep quality. However, this assessment of our data was not the main focus of the study, and our results were merely exploratory. To date, there is limited research investigating the relation between plant-based diets and sleep duration and quality. In this review, we focus on a recent study that has examined the relation between adherence to the Mediterranean diet and sleep in adolescents. [9] Our goal is to use this study as a launching point to explore how plant-based diets may affect sleep, and to provide suggestions for future research in this area.

Plant-Based Diet and Sleep Pattern

A recent study aimed to determine the association between adherence to the Mediterranean diet, sleep, and weight status among adolescents, age 11–14 y, living in Sicily, Italy. [9] A Mediterranean dietary pattern typically includes large amounts of fruits, vegetables, grains, and legumes; moderate amounts of dairy products (mostly cheese), low amounts of meat, and a high monounsaturated/saturated fat ratio (mostly from olive oil). [10] This cross-sectional study evaluated 1,586 adolescents through biometric testing and self-reported dietary and sleep measures. Demographic information included parental occupation and education level as well as the Physical Activity Questionnaire for Adolescents. Body composition was assessed using bioelectrical impendence analysis. Sleep patterns were determined with three questions addressed separately for weekday and weekend day: "What time do you usually go to bed?"; "What time do you usually wake up?"; "How many minutes did you sleep on any daytime naps?" Sleep duration was assessed by subtracting the self-reported sleep time from self-reported wake time and calculating the mean total weekday sleep time and the mean total weekend day sleep time in minutes. Bedtimes and wake times were categorized as <9 PM, 9–10 PM, 10–11 PM and >11 PM and <7 AM, 7–7:30 AM, and >7:30 AM, respectively. The study authors further classified adolescents by bedtime and wake time with the following categories based on median split: early bed-early rise (10:10 PM, 7 AM), early bed-late rise (10:15 PM, 7:30 AM), late bed-early rise (10:45 PM, 7:10 AM), or late bed-late rise (10:59 PM, 7:55 AM). Sleep duration across each

category ranged from 8.3 h (late bed-early rise) to 9.15 h (early bed-late rise). Sleepiness was assessed by the Pediatric Daytime Sleepiness Scale with higher scores indicating greater sleepiness. Lastly, diet was assessed with a food frequency questionnaire (FFQ) specifically developed for Italian adolescents. The FFQ scores were then used to calculate the Mediterranean Diet Quality Index for Children and Adolescents score which reflects adherence to a Mediterranean dietary pattern. Children were then classified as having poor, average, or good adherence to the Mediterranean dietary pattern based on those scores. Only 6% of the sample was considered to have good adherence to the Mediterranean diet.

Body mass index (BMI), fat mass percentage, and waist circumference were significantly lower in the early bed-late rise group. Linear regression models showed a statistically significant inverse relationship between sleep duration and BMI, fat mass percentage and waist circumference. Daytime sleepiness had a direct association with BMI and fat mass percentage. Fruit and vegetable consumption was found to have a significant positive association with total sleep time and weekday sleep time, but not weekend sleep time or sleepiness. Consumption of sweets, snacks, and eating outside the home were also associated with shorter sleep duration. Finally, the authors reported weak but significant linear relations between Mediterranean diet score and daytime sleepiness score, weekday sleep duration and total sleep duration. This study suggests that a healthy eating pattern and greater adherence to the Mediterranean diet may influence sleep quality, although causality cannot be established. Moreover, if such an eating pattern influences sleep, it is not clear which component or components of the Mediterranean dietary pattern would exert a stronger influence.

Limitations of the findings by Ferranti et al. include the prospective nature of the study design and recall bias from self-reported measures; only 6% of participants had good adherence to the Mediterranean diet; and the study was restricted to a small sample of Italian adolescents and perhaps may not be generalizable to other age groups and/or ethnic/racial or cultural backgrounds. [9] Plant-based protein intake from greater adherence to the Mediterranean diet may have been the underlying mechanism associated with improved sleep duration findings.

Studies unrelated to the Mediterranean region have also related plant-based food sources to sleep quality. In a cross-sectional study from Japan, associations between vegetable intake and sleep quality were observed in women. [11] All participants provided dietary information using a self-administered diet history questionnaire and sleep quality was assessed using the Pittsburg Sleep Quality Index. In logistic regression analyses, high intakes of vegetables and fish were related to good sleep quality, after adjusting for age, BMI, physical activity, depression, employment status, smoking, and alcohol intake. These data are corroborated by another cross-sectional study from Japan that performed principal component analysis to assess dietary patterns and examine their relation to sleep quality. [12] Greater adherence to a dietary pattern characterized by high intakes of vegetables, mushrooms, potatoes, seaweeds, soy and eggs was associated with a lower risk of encountering difficulty initiating sleep at least once weekly.

We have preliminary data showing that plant-based protein intakes are related to sleep quality from a cross-sectional study of women, age 20–75 years (n=106). [13] Sleep quality and duration were assessed using the Pittsburgh Sleep Quality Index and the Insomnia Severity Index. Dietary history was obtained using the Block Brief FFQ. Food items were coded as plant- or animal-based. Total protein was calculated for each food using the USDA Food Composition Database. The sum of daily protein from plant-based foods was calculated as a percentage of total daily caloric intake. In bivariate linear models, percentage of plant-based protein intake was positively associated with sleep duration (β=0.22, p=0.04). Higher percentage of plant-based protein intake was also associated with better sleep quality (β=−0.571, p= 0.02), and lower insomnia (β= −0.87, p=0.046). In bivariate logistic models, consuming ≥ 4% of energy from plant protein was associated with lower odds of short sleep duration (OR 0.27, CI 0.10–0.74, p=0.01) and there was a trend for higher sleep quality (OR 0.41, p=0.07). In multivariate adjusted logistic models, the association of plant-based protein intake with sleep duration was statistically significant (p =0.01); there was a trend for sleep quality (p < 0.11). These preliminary findings suggest a beneficial effect of plant-based protein intake on sleep but will clearly need confirmation using validated methods.

Potential mechanisms relating plant-based diet to improved sleep

Plant-based protein sources are rich in isoflavones. Cui et al. [14] have reported a cross-sectional relation between high isoflavone intakes and sleep quality in a Japanese population. More recently, Cao et al. [15] reported the 5-y longitudinal association between soy isoflavone intakes and sleep in a Chinese population. Isoflavone intake was assessed using a FFQ with a Chinese food composition table and overall dietary intakes were determined using a weighed 3-d food record. There was a lower odds of long sleep duration (≥9 h/night) in the highest isoflavone intake quartile relative to the lowest, after adjusting for sex, age, BMI, hypertension, and energy, fruit and vegetable, and meat intakes. Persistent high isoflavone intakes at baseline and at 5-y follow-up were associated with a lower likelihood of falling asleep during the day in women, but not in men. Finally, there was a persistent inverse association between isoflavone intake and sleep duration. The authors suggested that the estrogenic effect of isoflavones on arousals may be responsible for the reduced odds of long sleep duration and reduced likelihood of falling asleep during the day in women.

Plant-based proteins are also relatively high in the amino acid tryptophan, which is a precursor to melatonin and serotonin, two neurotransmitters involved in sleep regulation. The effects of a tryptophan supplementation on nocturnal sleep quantity and quality were assessed in elderly men and women experiencing sleep difficulties. [16] Participants were studied over a 3-wk period in which they were provided control cereal to consume daily at breakfast and dinner (22.5 mg tryptophan/30 g cereal) for one week followed by one week of daily consumption of a tryptophan-enriched cereal (60 mg/30 g) and one final week without cereal. Sleep was measured by wrist actigraphy and melatonin and serotonin were determined indirectly via their urinary metabolites, 6-sulfatoxymelatonin and 5-hydroxyindoleacetic acid, respectively. After one week of consuming the tryptophan-enriched cereal, total sleep time and sleep efficiency were increased and sleep onset latency, wake bouts, and sleep fragmentation were reduced relative to control. Sleep parameters were

similar between control and no-cereal weeks. At the end of the tryptophan-enriched cereal consumption week, melatonin and serotonin metabolites were increased relative to the other 2 study weeks and antioxidant capacity was also higher. These data suggest that the tryptophan content of plant-based diets may be involved in the positive relations observed between these dietary patterns and sleep. However, since tryptophan content of some animal proteins is also quite high, plant vs animal-based food sources of tryptophan should be compared in future studies.

Another potential mechanism by which plant-based diets could influence sleep quality is via improvements in body composition. Shah et al. [17] have reported that a higher quality dietary pattern, based on dietary components of a Mediterranean-style diet, was associated with lower BMI, visceral fat, pericardial fat, and liver fat in the Multi-Ethnic Study of Atherosclerosis. Interestingly, a weight loss intervention based on the Mediterranean diet, compared to a prudent diet, combined with physical activity counseling led to greater reductions in waist circumference and body fat, as well as in apnea/hypopnea index during rapid-eye movement sleep in patients with obstructive sleep apnea syndrome and obesity. [18] The reduction in apnea/hypopnea index during rapid-eye movement sleep was negatively correlated with increased exercise score and positively correlated with decreased waist circumference. Since improvements in apnea/hypopnea index were not adjusted for differences in change in body composition between groups, it is unclear whether those findings were a result of improved nutritional intakes or adiposity distribution. The authors highlighted a potential mechanism whereby reduced fat in the abdominal cavity could lead to improved respiration by allowing adequate expansion of the diaphragm. It is therefore not unreasonable to posit that a more desirable body composition, marked by lower body fat and abdominal adiposity, could contribute to the beneficial influence of a plant-based diet on sleep.

Tryptophan as a potential unifying factor in sleep-cardiovascular health relation

Herein we provide some evidence linking plant-based dietary patterns to good sleep quality. Recently, we have alerted the scientific community of the negative association between poor sleep and cardiovascular disease risk. [19] Given our knowledge of the cardiovascular health benefits of plant-based diets [20, 21], improvements in sleep may be an additional factor in the plant-based diet-cardiovascular disease relation. Indeed, Mirmiran et al. examined the association between dietary protein and amino acid intakes and risk of cardiovascular disease in the Tehran Lipid and Glucose Study. [22] They found no significant association between plant-based protein or animal-based protein intake, assessed using a 168-item FFQ, and incidence of cardiovascular disease over the 6.7 y of follow-up. However, using principal component analyses, they determined 3 different amino acid patterns in their population: (1) high in lysine, methionine, valine, aspartic acid, tyrosine, threonine, isoleucine, leucine, alanine, histidine, and serine; (2) glycine, cysteine, arginine, and tryptophan; (3) proline and glutamic acid. Only pattern 2, which included tryptophan, was associated with a reduced risk of cardiovascular disease-related events. There was a 28% reduction in risk with every 1 SD increase in pattern 2 score. Circulating tryptophan

concentrations were also inversely associated with non-stroke cardiovascular events in a sub-sample of participants from the PREDIMED study. [23] Participants in the two Mediterranean diet groups had increases in tryptophan concentrations and this was related to lower non-stroke outcomes. The authors suggested that changes in tryptophan may be involved in the cardio-protective effects of the Mediterranean diet. Sleep and sleep-related metabolite derivatives of tryptophan, melatonin and serotonin, were not measured in this study. Nevertheless, given our understanding of tryptophan metabolism, sleep improvements may have further played a role in this observation (Figure 1).

Conclusions

Poor sleep duration and quality are known to be associated with poor food choices, unhealthy dietary intakes, and increased risk of cardiovascular disease. We can hypothesize that sleep may not only impact cardiovascular disease risk directly, but also via its influence on other lifestyle behaviors known to adversely affect cardiovascular health (Figure 2). Here, we propose that the association between sleep and diet can also be reversed: healthy food choices may improve sleep health. It could therefore be similarly hypothesized that an additional heart-health benefit of plant-based diets is good sleep. However, studies to date have largely been epidemiological, and have failed to combine robust and objective measures of sleep and diet. Future studies should examine the influence of dietary patterns on sleep health. Perhaps this could lead to uncovering yet another benefit of following heart-healthy dietary guidelines to increase intakes of plant-based foods.

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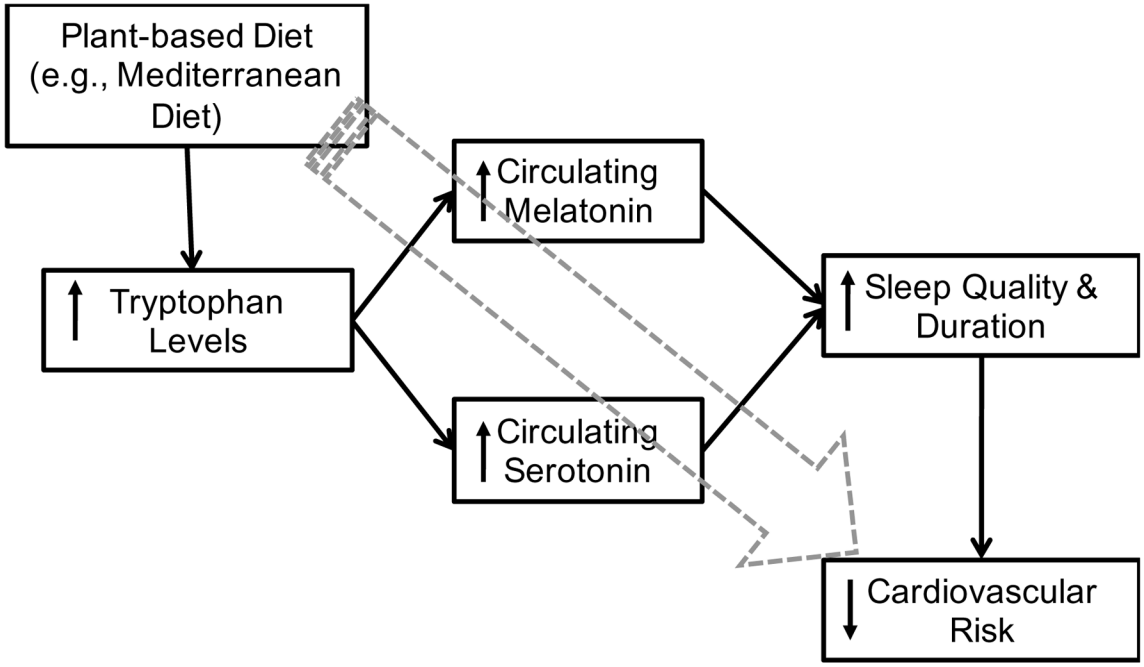

Figure 1.

Novel pathway through which plant-based diets may influence sleep and cardiovascular risk. A plant-based diet may lead to increased levels of the amino acid tryptophan, leading to increased melatonin and serotonin metabolites, enhancing sleep quality and quantity, and thus reducing cardiovascular risk.

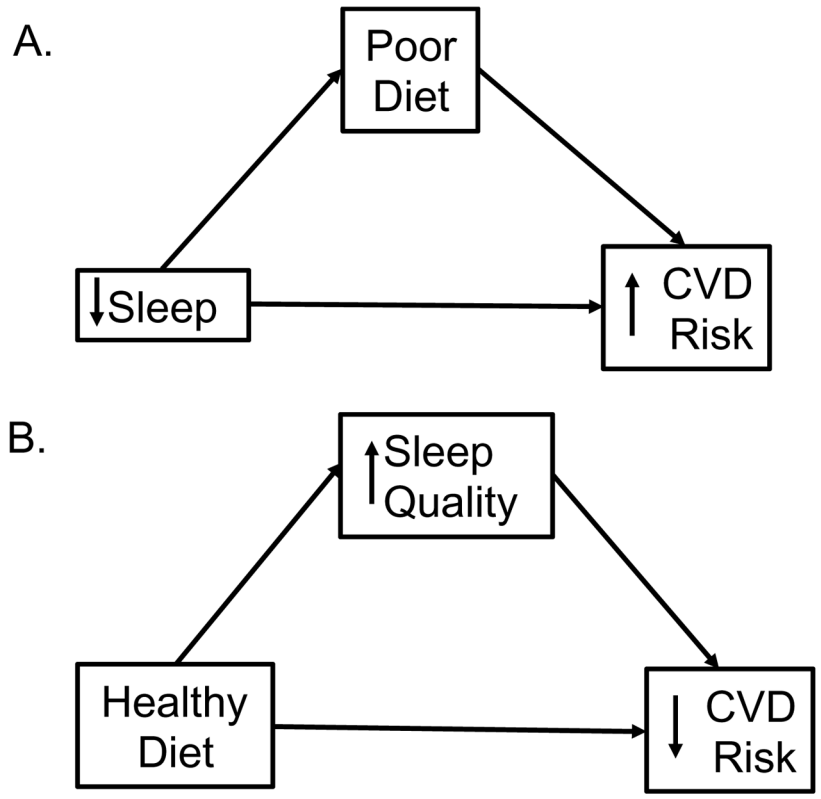

Figure 2.

Poor sleep can adversely affect cardiovascular health directly or indirectly, via changes in dietary quality (A). A novel proposition is that a healthy diet can affect cardiovascular disease risk directly and indirectly, via improvements in sleep (B).