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Higher daytime intake of fruits and vegetables predicts less disrupted nighttime sleep in younger adults

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ABSTRACT

Background: Higher-quality diets are associated with better sleep quality in observational studies. However, a better understanding of this association is needed given that dietary modifications could represent a novel and natural approach to achieve better sleep.
Objective: To examine how daytime dietary intakes influence sleep quality on the following night using multiple days of self-reported diet monitoring and objective sleep measured under free-living conditions.
Methods: Participants were younger US adults with average habitual sleep duration between 7 and 9 hours per night. Diet was assessed using the Automated Self-Administered 24-Hour Dietary Assessment Tool. Sleep was measured using wrist actigraphy. Sleep fragmentation index was used for objective assessment of sleep quality.
Results: Thirty-four participants (age: 28.3 ± 6.6 years, BMI: 24.1 ± 3.9 kg/m^2, 82.3% males, 50.0% racial/ethnic minority) provided 201 paired diet-sleep data. Greater daytime intakes of fruits and vegetables (β-coefficient (SE) = −0.60 (0.29), P = .038) and carbohydrates (−0.02 (0.007), P = .022), but not added sugar (P = .54), were associated with lower sleep fragmentation index. Trends toward associations of higher intakes of red and processed meat (P = .10) with more disrupted sleep, as well as higher fiber (P = .08) and magnesium (P = .09) intakes with less disrupted sleep, were observed.
Conclusions: Higher daytime intakes of fruits and vegetables and carbohydrates that align with a healthy diet were associated with less disrupted nighttime sleep. A 5-cup increase (from no intake) in fruits and vegetables, meeting dietary recommendations, was associated with 16% better sleep quality. These findings suggest that diets rich in complex carbohydrates, fruits, and vegetables may promote better sleep health.
Clinical trial registry: NCT03663530 and NCT03257137

Introduction

Sleep and diet are key determinants of cardiometabolic health[1] with substantial public health relevance given the potential to intervene on these lifestyle behaviors. Insufficient sleep, that is, sleep duration below the recommended 7-9 hours per night[2] or poor indicators of sleep quality,[3] is a widespread problem with many negative health consequences, particularly in younger adults.[1] It is

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widely recognized that insufficient sleep results in unhealthy diets (e.g., higher in energy, total fat, and added sugars),[4-6] but less is known about how dietary intakes influence sleep patterns. This gap in research is of high public health importance because dietary modifications could represent a novel and natural approach to promote better sleep quality. In this regard, population-based observations have highlighted a potential role of diet as a modulator of sleep quality.[7-10] In diverse epidemiological cohorts, healthy dietary patterns have been associated with favorable self-reported sleep outcomes.[11-16] However, the temporality of the association between consumption of a healthier diet and obtaining good sleep quality remains to be elucidated. Clinical intervention studies that directly examined the impact of diet on sleep quality have largely tested individuals under controlled laboratory conditions using extreme experimental diets with varying macronutrient content[17-28] or specific food items,[29-37] with little attention paid to food groups and overall dietary nutrient profile. Although these intervention studies provide important insights into the directionality of the association between diet and sleep quality, they do not necessarily inform how habitual dietary patterns influence sleep quality in real-life settings.

We have previously shown that women who consume a diet that more closely aligns with a Mediterranean profile report better sleep quality, higher sleep efficiency, and fewer sleep disturbances at 1-year follow-up.[12] Diet was assessed by food frequency questionnaire and sleep was assessed by validated surveys.[12] In that study, fruit and vegetable consumption predicted better self-reported sleep quality, higher sleep efficiency, and fewer sleep disturbances. The current study sought to build on these self-reported findings and assess how daytime dietary patterns predict objectively measured sleep quality on subsequent nights, providing a temporal order and thus novel insights into the directionality of the association between diet and sleep quality. We hypothesized that daytime consumption of a diet higher in fruits, vegetables, whole grains, nuts and seeds, and healthy fats, and lower intakes of added sugar, saturated fat, and red and processed meats would predict better objective sleep quality during the subsequent night.

Methods

Participants

Participants were recruited at Columbia University Irving Medical Center and at the University of Chicago through local and online advertisements, to participate in two separate studies examining the influence of diet and meal timing on sleep and energy balance (Supplementary Fig.). Participants were healthy males and females (age range: 20-49 years, BMI range: 19.0-34.9 kg/m^2) who were stable weight, reported habitual sleep duration between 7 and 9 hours per night, and who regularly consumed three meals per day. Individuals were ineligible if they reported having sleep problems, were diagnosed for sleep apnea or were at high risk for sleep apnea by questionnaire,[38] or had a history of sleep disorders. Additional exclusion criteria were night or rotating shift work, habitual daytime napping, travel across time zones within the past 4 weeks, extreme morning or evening chronotypes, self-reported excessive alcohol (> 14 drinks/week for females and > 21 drinks/week for males) or caffeine (> 300 mg/d) intake, smoking within the past 3 years, illicit/recreational drug use, participation in a weight loss or behavioral lifestyle modification (diet or exercise) program, food allergies/intolerances, currently pregnant or lactating within the past year, or any significant acute or chronic medical condition, past or current eating disorder, or psychiatric disorder. Both study protocols were approved by the Institutional Review Boards of their respective institutions and participants provided written informed consent.

Study protocols

The study at Columbia University Irving Medical Center (NCT03663530) was a randomized crossover study with two phases consisting of 6 weeks with a minimum 4-week washout period between phases to ensure no carryover effects of the intervention. Phases differed in the timing of a 10-hour eating window relative to morning wake time: either starting 1 hour post awakening or 5 hours post awakening.[39] During the first 2 weeks of each study phase, a controlled diet was provided by the Bionutrition Unit of the Irving Institute for Clinical and Translational Research. During the last 4 weeks of each study phase, participants self-selected their food intake while maintaining the prescribed eating window. The phase with the eating window starting 1 hour post awakening represented our participants' habitual eating behavior and data from this phase only were used in the present analyses.

The sample from the University of Chicago consisted of participants who were assessed for eligibility for a clinical laboratory study (NCT03257137) that investigated the effect of two dietary interventions on sleep outcomes in the laboratory setting. Prior to becoming eligible for the study, participants were monitored for 1 week under free-living conditions while they continued their habitual diet and sleep patterns. In the current analyses, self-reported dietary and objective sleep data collected from participants during the free-living week were used.

Dietary intake measurements

In both studies, only data capturing habitual eating patterns were used, and dietary intake was monitored using the Automated Self-Administered 24-Hour (ASA24) Dietary Assessment Tool from the National Cancer Institute.[40] Participants completed multiple days of 24-hour dietary records and sleep measurements. They were instructed to record all foods and beverages consumed during each 24-hour period, including water. Participants enrolled at Columbia University Irving Medical Center completed two sets of 3-day food records, 2 weeks apart, reporting on two nonconsecutive weekdays and one weekend day (5.4 ± 0.7 days per participant recorded). Participants enrolled at the University of Chicago completed 24-hour dietary records on 7 consecutive days (6.1 ± 1.7 days per participant recorded). Diet variables, including total energy intake, macronutrients (carbohydrates, protein, fat, and fiber), micronutrients relevant to sleep (magnesium, vitamin B6, vitamin D, calcium, sodium, and zinc), and food groups (fruits and vegetables, nuts and seeds, whole grains, refined grains, added sugar, soy and legumes, dairy, and red and processed meat), were assessed. Although alcohol is known to influence sleep, we did not include alcohol in our statistical models because about two-thirds of participants (20/34 [58.8%]) reported 0 days of alcohol consumption and the percentage of days with no alcohol ranged from 42.9%-100%. Records with implausible values for reported energy intakes (females: > 4400 or < 600 kcal/day; males: > 5700 or < 650 kcal/day), protein (females: > 180 or < 10 g/day; males: > 240 or < 25 g/day), and fat (females: > 185 or < 15 g/day; males: > 230 or < 25 g/day), based on cut points for nutrient outliers published by the National Cancer Institute,[41] were excluded from the analyses.

A total of 218 individual days/nights of paired diet-sleep data were available. Seventeen records were excluded due to implausible dietary data (2 records for energy only; 5 records for protein only; 6 records for fat only; 4 records for a combination of energy/fat/protein) resulting in 201 individual days/nights of diet-sleep data included in the final analyses. Overall, the participants provided an average of 5.9 ± 1.6 days of paired diet-sleep data.

Sleep measurements

At the study entry, participants completed the Pittsburgh Sleep Quality Index (PSQI) to capture their subjective sleep quality over the prior 4 weeks.[38] In both studies, sleep was objectively monitored using wrist actigraphy, a triaxial accelerometer worn on the nondominant wrist (Actigraph GT3X+, ActiGraph LLC, Pensacola, FL at Columbia University Irving Medical Center and Actiwatch Spectrum Plus, Philips at the University of Chicago). The device was worn at all times throughout the data collection period. Sleep diaries were collected concurrently with wrist actigraphy monitoring for accurate data analysis and interpretation. Sleep scores were automatically generated by validated sleep scoring algorithms using actigraphy data analysis software, while incorporating, as needed, additional information on the participant's sleep behavior from their sleep diary. Sleep fragmentation index (SFI) derived from wrist actigraphy, was used as an objective measure of sleep quality. SFI is an indicator of sleep disruption expressed as the ratio of the number of awakenings to the total sleep time in minutes. Lower SFI indicates less disrupted sleep (better sleep quality), while higher SFI indicates more disrupted sleep (worse sleep quality). Sleep efficiency was defined as percent of time in bed spent asleep.

Statistical analysis

Linear mixed-effects models were constructed to examine the relation between dietary intake variables during the day and SFI on the corresponding night, with a random intercept added for each participant. Sex and race and ethnicity were considered as covariates but were not significant predictors, so they were removed from the final analyses. In addition, a separate model was run adjusting for total energy intake for outcomes of macro- and micronutrients and food groups. Means ± SDs are reported for descriptive statistics, and regression coefficients and standard errors are reported for the linear mixed-effects models. Analyses were performed using SAS version 9.4 and Stata version 18, and the results were considered significant at $P < .05$. No adjustment for multiple comparisons was made.

Results

Participant demographic and sleep characteristics

Participants' demographics and sleep data are shown in Table 1. The sample consisted of 28 males and 6 females (N = 34), 8 recruited at Columbia University Irving Medical Center and 26 at the University of Chicago. Average age and BMI were 28.3 ± 6.6 years and 24.1 ± 3.9 kg/m^2, respectively, and 50.0% of the sample identified as a racial/ethnic minority. Overall, participants had an average habitual sleep duration of 423.2 ± 69.9 minutes (7 hours 3 minutes) per night, that is, within the range of average healthy sleep duration recommendation of 7-9 hours per night. On average, sleep efficiency was 89.3% ± 5.8%, wake after sleep onset was 34.4 ± 16.6 minutes, and the SFI was 17.5 ± 9.4. The average PSQI global score was 3.0 ± 1.4, indicating overall good self-reported sleep quality (a global score > 5 indicates poor sleep quality).

Table 1
Participant demographic and sleep characteristics[a]

Characteristic	Study participants (n = 34)
Age (y)	28.3 ± 6.6
BMI (kg/m^2)	24.1 ± 3.9
Race	
Black/African American	3
White	19
Asian	7
More than one race	2
Other	3
Ethnicity	
Hispanic/Latino	8
Non-Hispanic/Latino	26
Pittsburgh Sleep Quality Index global score	3.0 ± 1.4
Total sleep time (min)[b]	423.2 ± 69.9
Sleep onset latency (min)[b]	7.7 ± 10.3
Sleep efficiency (%)[b]	89.3 ± 5.8
Wake after sleep onset (min)[b]	34.4 ± 16.6
Sleep fragmentation index (%)[b]	17.5 ± 9.4

[a] Data presented as mean ± SD or n.
[b] Assessed by wrist actigraphy.

Dietary intakes

On average, participants consumed 2085 ± 743 kcal/day, with 45.1% ± 8.7% energy from carbohydrates, 18.2% ± 5.2% energy from protein, and 36.0% ± 8.6% energy from fat (Table 2), on par with reported intakes for the average American adult.[42] Participants exceeded the recommendations for dietary saturated fat (< 10% kcal/day) and did not meet recommendations for intakes of dietary fiber (≥14 g/1000 kcal), fruits (≥2 cups/day), and vegetables (≥2.5 cups/day). Intakes of whole and refined grains fell below and above recommended amounts, respectively (whole grains: ≥3 oz/day, refined grains: ≤3 oz/day per 2000 kcal). Dairy intakes also fell below the recommended quantity (≥3 cups/day), while sodium intakes exceeded the recommended limit (≤2300 mg/day).

Associations between daytime dietary intakes and SFI

Greater fruit and vegetable intakes during the day were associated with lower SFI during the subsequent night (β(SE) = −0.60(0.29), P = .038), suggestive of less disrupted sleep (Table 3, Fig. 1). Based on these prediction models, a 5-cup increase (from no intake) in fruits and vegetables was associated with a 16% reduction in SFI. Adjusting for total energy intakes attenuated this association (β(SE) = −0.54(0.30), P = .071). A trend toward more fragmented sleep was observed for red and processed meat intakes (β(SE) = 0.37(0.22), P = .098). Adjusting for energy intakes strengthened the association, although it did not reach statistical significance (β(SE) = 0.43(0.23), P = .057). Greater carbohydrate intakes during the day were associated with lower SFI during the subsequent night (β(SE) =

Table 2
Dietary intakes measured by ASA24[a]

Diet variable	All (n = 34)
Energy (kcal)	2085 ± 743
Energy density (kcal/g)	1.7 ± 0.5
Protein (g)	94.5 ± 42.9
Carbohydrates (g)	232.9 ± 89.1
Total fat (g)	83.6 ± 37.8
Saturated fat (g)	26.2 ± 12.8
Unsaturated fat (g)	49.8 ± 24.7
Fiber (g)	20.7 ± 10.7
Magnesium (mg)	329.3 ± 153.8
Vitamin B6 (mg)	2.3 ± 1.7
Vitamin D (mcg)	5.3 ± 6.5
Calcium (mg)	963.6 ± 526.2
Sodium (mg)	3794 ± 1717
Zinc (mg)	11.7 ± 5.7
Fruits and vegetables (cups)	3.0 ± 2.1
Nuts/seeds (oz)	0.8 ± 1.6
Whole grains (oz)	1.0 ± 1.4
Refined grains (oz)	6.4 ± 3.6
Added sugar (tsp)	8.1 ± 7.3
Soy and legumes (oz)	0.8 ± 1.4
Dairy (cups)	1.6 ± 1.5
Red and processed meat (oz)	2.2 ± 2.4

[a] Data presented as mean ± SD.

Table 3
Associations of dietary intakes with sleep fragmentation index[a]

	Sleep fragmentation index (SFI)	
Diet variable	β-coefficient ± SE	*P* value
Energy (kcal)	−0.0011 ± 0.00084	.20
Energy density (kcal/g)	0.87 ± 1.19	.47
Protein (g)	−0.015 ± 0.015	.30
Carbohydrates (g)	−0.016 ± 0.0070	.022*
Total fat (g)	−0.0034 ± 0.016	.83
Saturated fat (g)	0.0096 ± 0.043	.83
Unsaturated fat (g)	−0.011 ± 0.024	.64
Fiber (g)	−0.10 ± 0.058	.083
Magnesium (mg)	−0.0074 ± 0.0044	.091
Vitamin B6 (mg)	−0.23 ± 0.35	.50
Vitamin D (mcg)	−0.015 ± 0.08	.86
Calcium (mg)	−0.00080 ± 0.0012	.51
Sodium (mg)	−0.00036 ± 0.00039	.36
Zinc (mg)	0.085 ± 0.098	.39
Fruits and vegetables (cups)	−0.60 ± 0.29	.038*
Nuts/seeds (oz)	−0.074 ± 0.39	.85
Whole grains (oz)	0.034 ± 0.42	.94
Refined grains (oz)	−0.16 ± 0.15	.27
Added sugar (tsp)	0.056 ± 0.092	.54
Soy and legumes (oz)	−0.18 ± 0.39	.65
Dairy (cups)	−0.40 ± 0.43	.36
Red and processed meat (oz)	0.37 ± 0.22	.098

[a] Data presented as β ± SE and *P* value. β are regression coefficients from linear mixed-effects models for a 1-unit increase in the diet variable and *P* values are marked with * when significant at $P < .05$.

−0.016(0.007), $P = .022$), suggestive of less disrupted sleep. Adjusting for total energy intakes increased the strength of this association (β(SE) = −0.026(0.012), $P = .032$). The findings were not changed when study site was added as a covariate to regression models in sensitivity analyses: greater daytime intakes of fruits and vegetables (β-coefficient (SE) = −0.61(0.29), $P = .04$) and carbohydrates (−0.02(0.007), $P = .02$) were associated with lower SFI.

Of note, added sugar intake was not associated with SFI in unadjusted models (β(SE) = 0.06(0.09), $P = .54$) or in models adjusting for energy intake (β(SE) = 0.11(0.10), $P = .26$). A trend was observed for higher fiber intakes to be associated with less fragmented sleep (β(SE) = −0.10(0.06), $P = .083$) but this was no longer observed after adjusting for energy intakes (β(SE) = −0.08(0.06), $P = .19$).

A trend for less fragmented sleep was observed with higher intakes of magnesium (β(SE) = −0.0074(0.0044), $P = .091$). This trend disappeared after adjusting for energy intakes (β(SE) = −0.0065 (0.0058), $P = .26$). No significant associations were observed for other food groups, macronutrients, or micronutrients.

Discussion

This study showed that, in a sample of younger adults, greater daytime intakes of fruits and vegetables were associated with less disrupted sleep at night, as reflected by lower SFI, assessed by wrist actigraphy. Accordingly, we also found that carbohydrates and fiber, but not added sugar, were related to better sleep quality. These findings suggest that carbohydrates and fiber from fruits and vegetables are most likely contributing to better sleep quality with less sleep fragmentation. These findings provide evidence of a temporal association between habitual daytime dietary patterns and sleep quality, aligning with previously observed associations in longitudinal population studies.[12,13,15,16,43] However, given the observational nature of the data, causality cannot be inferred. Nonetheless, based on these temporal associations, our findings highlight a potential role of higher fruit and vegetable intakes for improving sleep health, although additional research is needed to evaluate mechanisms and causality.

We found that higher daytime fruit and vegetable intakes were associated with less disrupted sleep using objective sleep assessment by actigraphy. High fruit and vegetable intakes have previously been associated with better self-reported sleep quality in observational studies.[12,13,15,16,44] In contrast to our study, these prior observational studies used self-reported sleep outcomes. Moreover, most of those studies were performed predominantly in female participants[10,11,14] and middle-aged to older adults.[11,13,14,41]

It has been hypothesized that fruits and vegetables may be linked to sleep through their complex carbohydrate content, including fiber, polyphenolic profile, and melatonin content. Potential mechanisms have been proposed to explain the role of carbohydrate intakes on sleep quality.[45,46] The most supported theory is that carbohydrates consumed in the diet facilitate increased uptake of dietary tryptophan by the brain, thereby increasing brain synthesis of serotonin, which is subsequently converted to sleep-promoting hormone, melatonin.[9,47] Another theory, though not well-studied, postulates that diet may modulate sleep through stimulation of glucose-sensing neurons in the hypothalamus.[48] This proposed mechanism presumes that high glucose levels reduce activity of orexin neurons and increase activity of melanin-concentrating hormone neurons, promoting sleep state.[48] However, further controlled studies are needed to confirm these mechanisms.

It is also possible that other nutritive and non-nutritive compounds present in fruits and vegetables explain their positive impact on sleep quality. Fruits and vegetables are excellent sources of polyphenols and higher polyphenol intakes have been linked to better overall sleep quality in observational studies.[49-51] These non-nutritive components could conceivably influence gut microbiome-brain communications that could be beneficial to sleep quality.[52] Fruits and vegetables can also increase circulating melatonin levels,[32,53,54] and prior studies supplementing the participants' diet with specific fruits and vegetables high in melatonin have reported improved sleep quality.[32] For example, in one study, consuming tomatoes for 8 weeks increased melatonin production, and improved self-reported sleep quality relative to a non-tomato-consuming group of postmenopausal women.[30] In another study, tart cherry juice consumption similarly increased melatonin production and sleep duration, measured with actigraphy, in healthy young men and women.[27]

Our findings show that higher carbohydrate intakes, but not added sugar, are associated with less disrupted sleep at night. Studies of varying carbohydrate intakes in relation to other macronutrients have had mixed findings with regard to the impact of carbohydrates on sleep quality. Clinical in-laboratory intervention studies testing the effects of high-to-moderate carbohydrate intakes as compared with low-carbohydrate intakes on objective sleep quality measured by polysomnography, have shown higher rapid eye movement sleep,[25,27,28,55] lower slow-wave sleep,[19,25,28] higher sleep efficiency,[22] and lower sleep onset latency[17,22] after higher carbohydrate intakes. Studies that objectively measured sleep by wrist actigraphy to compare the effects of high- vs. low-carbohydrate diets have observed decreased wake time[21] and shorter sleep onset latency[20] with higher carbohydrate intake.

In our study, added sugar intake was not significantly associated with sleep quality, as quantified by actigraphy-measured SFI. In prior work, added sugar intakes were associated with greater sleep difficulties[43] possibly due to more arousals at night.[56] However, the latter study measured food intake directly, through weighed in-laboratory methods, rather than through self-report in real-world settings, as in the present study, which may partly explain the discrepancy in findings. Our findings suggest that healthier carbohydrate sources, from fruits and vegetables, are beneficial to sleep quality.

We have also observed a trend toward higher red and processed meat intakes being associated with higher SFI. Consistent with our

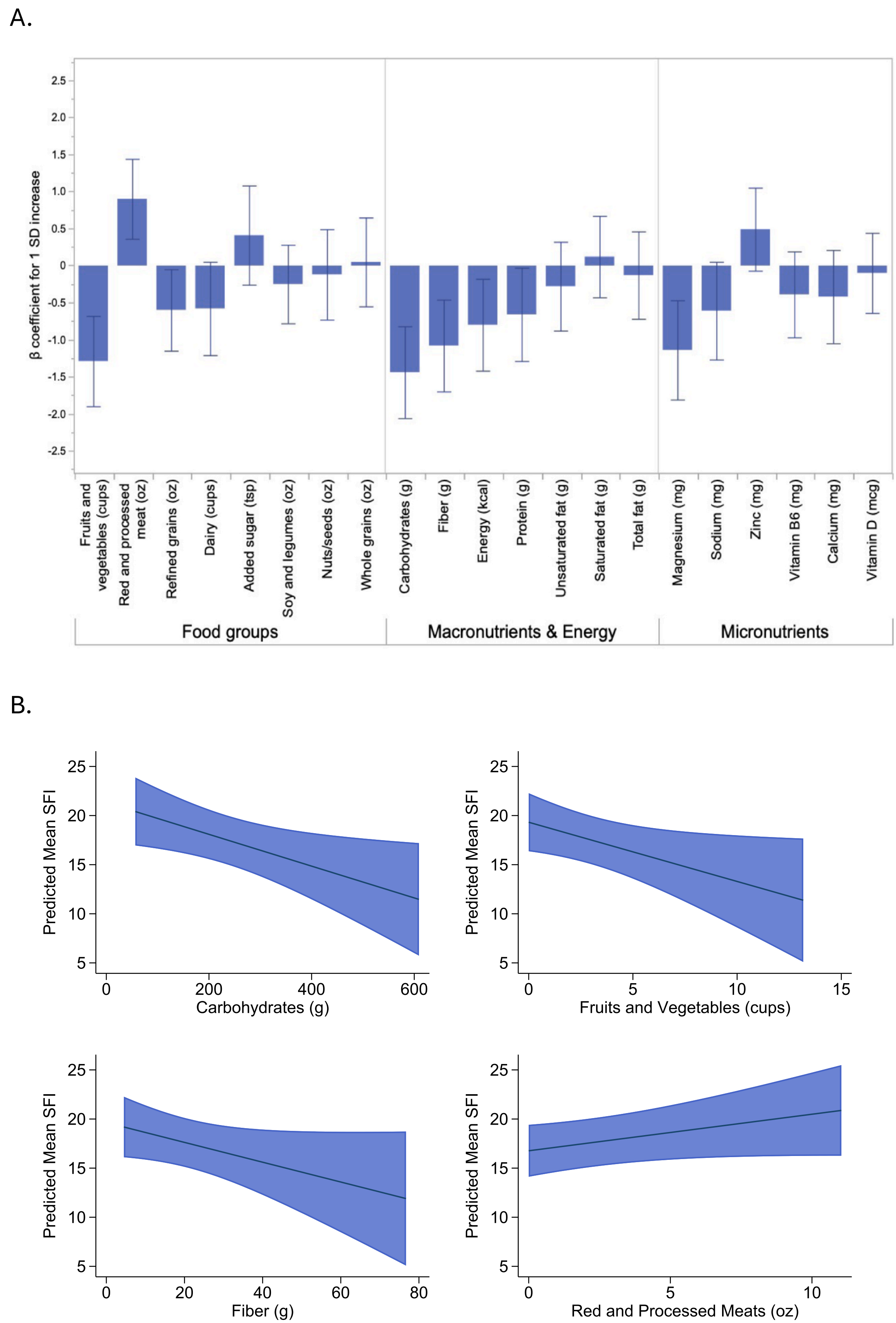

Fig. 1. (A) Associations between dietary intakes and sleep fragmentation index (SFI). Bar plot of regression coefficients (per 1 standard deviation increase in dietary measures to make effects on sleep fragmentation index more directly comparable) from linear mixed-effects models. Error bars represent +/- 1 SE. (B) Food groups and macronutrients with strongest effects on the SFI. Greater intake of carbohydrates and fruits and vegetables predicts lower SFI (better sleep quality). Trends were observed for higher fiber and lower red and processed meat intakes predicting lower SFI (better sleep quality). Estimates are from linear mixed-effects models (see also Table 3). The shaded areas represent 95% confidence bounds for the estimates

findings, a cohort study of older adults showed an association between higher red and processed meat intakes and poorer overall self-reported sleep quality.[57] In another study, higher red and processed meat consumption was associated with poorer self-reported sleep quality in pregnant women,[58] which was attributed to the high protein content of the meal. This is unlikely to be an explanation for our findings, as protein intake was within the recommended range. Red and processed meats are sources of dietary saturated fat, which we have shown to be associated with less deep sleep,[56] and could explain some of our findings.

A major strength of our study is the assessment of a temporal relation between daytime dietary patterns and objectively measured sleep quality at night using paired diet-sleep data from 201 individual days/nights collected under free-living conditions. This unique dataset allowed us to examine a direct impact of daytime dietary intakes on subsequent nighttime sleep in real-life settings, which enhances the ecological validity of our findings. The dietary data were captured using self-report, which may be a limitation. However, it is mitigated, at least partially, by the collection of multiple days of food records from the same participants and the use of a standardized, rigorous measure of free-living dietary intakes. As with any dietary assessment, knowledge that diet would be evaluated could have altered our participants' usual habits. However, this would not have any impact on the observed relation with sleep at night, which was measured objectively. Nonetheless, it is possible that some potential confounding from behavioral factors (e.g., stress, physical activity) or undiagnosed sleep disorders (e.g., sleep apnea) could influence our findings. Our participants were lean younger adults and thus not a high-risk population for sleep apnea. We studied younger adults, mostly males, and used selective eligibility criteria, which may limit generalizability to other populations. Given sex differences in eating and sleeping behaviors, additional research with a balanced ratio of males and females would be necessary. The relatively small number of participants may have limited to some extent the variability in dietary intakes and may have potentially reduced our ability to detect other significant associations between dietary intakes and sleep quality. Our data were collected over relatively brief periods, and thus future research examining temporal relationships is needed to address longer-term effects of diet on sleep. On average, our participants reported good sleep quality at study entry and had adequate sleep duration, which may partly limit our ability to detect larger effects of diet on sleep. Also, we did not test the influence of a prescribed diet on sleep quality to evaluate causality. Finally, habitual eating patterns and objective sleep data in free-living conditions from two separate studies, one of which included an intervention, were merged, which may influence our findings. However, in sensitivity analyses, when the study site was included as a covariate in our statistical models, the conclusions remained similar, which supports the robustness of our findings despite the different settings in which participants were studied.

In conclusion, we have found that, in younger adults, higher habitual daytime intakes of fruits and vegetables and carbohydrates are associated with less sleep disruption (less sleep fragmentation) and thus better objective sleep quality in a real-life setting. Based on our model predictions, for example, a person eating the recommended 5 cups of fruits and vegetables per day would have an expected SFI of 16.3, while someone not consuming any fruits and vegetables (i.e., 0 cups) would be expected to have an SFI of 19.4. Thus, a 5-cup increase (from no intake) in fruits and vegetables, meeting dietary recommendations, would be associated with 16% better sleep quality. These findings suggest that increasing intakes of complex carbohydrates, particularly from fruits and vegetables, may promote healthier sleep. Importantly, our findings show for the first time a temporal link between healthy habitual daytime dietary profile and better sleep quality during the subsequent night, strongly suggesting that dietary patterns high in plant foods may provide better sleep quality. Future research, including large-scale randomized controlled trials in diverse populations, is necessary to further investigate the relationship between plant-forward dietary patterns and sleep health, identify underlying mechanisms, and evaluate racial/ethnic differences.

Author contributions

MPSO and ET designed research, HLB, KDW, JMK, and BT conducted research, WQ, BC, and KEW analyzed or interpreted data, HLB, KDW, JMK, BT, ET, and MPSO wrote the paper, and ET and MPSO had primary responsibility for final content. All authors have read and approved the final paper.

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Data availability

Data described in the paper, code book, and analytic code will be made available upon request to the senior authors.

Declaration of conflicts of interest

The authors have no financial or personal conflicts of interest to disclose.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.sleh.2025.05.003.

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