Original Article

Bedtime banana and milk intake on sleep and biochemical parameters

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Background and Objectives: This study aimed to evaluate the effects of milk and banana given as a bedtime snack to patients with primary insomnia on sleep parameters and some biochemical parameters such as brain-derived neurotrophic factor, leptin, and ghrelin. **Methods and Study Design:** 21 patients with insomnia who met the inclusion criteria participated in this study. The patients were divided into 3 parallel groups: banana, milk and control. The intervention group were given either 1 portion of banana or just 200 mL of whole-fat milk at bedtime. The control group did not consume any non-routine food. Venous blood samples were taken at baseline and after the study from patients to measure brain-derived neurotrophic factor, leptin and ghrelin concentrations. Sleep quality and architecture were determined by polysomnography and Pittsburg Sleep Quality Index. **Results:** Pittsburg Sleep Quality Index scores of the banana and milk group were found to be lower after intervention ($p<0.05$). In terms of polysomnography, the total sleep time of the milk group was found to be significantly higher than baseline. Serum ghrelin concentration of the milk group decreased significantly compared to baseline. **Conclusions:** Bedtime milk or banana intake was effective in dealing with insomnia. Foods rich in tryptophan, such as banana and milk, given at bedtime, may improve sleep parameters and appetite hormones.

Key Words: appetite, banana, bedtime, milk, sleep

INTRODUCTION

Sleep is one of the essential factors that plays a crucial role in the maintenance of the circadian system. Sleep quality (low number of awakenings >5 min, less awakening after the onset of sleep, etc.) and sleep duration (7-9 h/day) affects the general health status of individuals.[1-3] Many restorative and regulatory functions of the human body, such as memory, mental restoration, mood and behavior, are also associated with sleep.[4] Despite the importance of adequate sleep, approximately 45% of Australian and American adults do not have the recommended 7-9 h of sleep per day.[5]

Insomnia is the most common form of sleep disorder. It is characterized by one or more of the following characteristics: difficulty in initiating or maintaining sleep and/or waking up too early. Long work hours, alcohol consumption, or being overweight are prominent factors associated with shorter sleep duration and indirectly insomnia.[6-8] Insomnia is linked to many common public health issues. For example, insomnia is strongly linked to obesity and diabetes, thereby indirectly increasing the prevalence of cardiovascular diseases and mortality reciprocally. Furthermore, cognitive dysfunction such as memory problems and difficulty in focusing are other comorbid factors that may relate to insomnia.[8,9] Previous studies show that diet may be considered as an alternative treatment to reduce sleep disturbances.[10,11]

Foods, especially, those high in tryptophan and melatonin may improve sleep disorders. Foods consumed before bedtime may have a strong effect on sleep.[12] Foods that are especially rich in tryptophan given before bedtime helps release insulin, which will draw large amino acids into the muscle tissues and allow tryptophan to cross the blood-brain barrier, thus promoting the synthesis of serotonin and melatonin. Bananas and milk are tryptophan-rich foods that are known to have sleep-inducing effects. However, there has been no study that studies their effects on sleep using objective methods. The aim of the study was to determine the effect of 6-week bedtime banana and milk intervention on sleep quality and on Brain Derived Neurotrophic Factor (BDNF), leptin, and ghrelin concentrations in patients with insomnia. We hypothesize that banana and milk treatment for 6-weeks at bedtime may improve sleep parameters.

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METHODS

Participants

Patients with insomnia were included in the study between July 2022 and February 2023 in a neurology outpatient clinic at one of the university hospitals. Patients with insomnia were diagnosed by neurologists through American Sleep Medicine Academy criteria in the neurology department of the hospital.

Inclusion criteria were: patients diagnosed with insomnia; aged 18 to 45 years; and BMI 18.5-24.9 kg/m^2 according to Word Health Organisation (WHO) classification. Exclusion criteria were patients that did not have any acute or chronic psychological and medical conditions, as determined by questionnaires, interviews, physical exams, clinical history, and urine and blood tests; not taking any regular medications (except oral contraceptives); smokers. Other exclusion criteria were pregnant and lactating women; those who engaged in extreme physical activity; and allergic to banana or milk. Two of the 23 subjects who were accepted in this study dropped out. Finally, 21 eligible subjects completed the study with no adverse events.

All patients provided written informed consent in accordance with the Declaration of Helsinki. The protocol was approved by the Selcuk University Faculty of Medicine Clinical Research Ethics Committee (2022/02). The present study was registered at ClinicalTrials.gov (ClinicalTrials.gov Identifier: NCT05420090).

Procedure

This study employed a controlled-prospective design. The total study duration was 6-weeks with two different intervention groups and a control group. Patients with insomnia were diagnosed by neurologists through American Sleep Medicine Academy criteria in the neurology department of the hospital. Using G*Power software (http://www.gpower.hhu.de/) and specifying a significance level of 0.05 and a power of 95%, a sample size was identified as 21 patients according to the total sleep time for subjective measurements (Cohen's d effect size (d): 1.93).[13] Subjects were not randomized but were allowed to choose to be in one of the following groups: (a) banana group (1 portion banana (85-100 g) consumed before bedtime), (b) milk group (200 mL whole-fat milk before bedtime), or (c) control group (follow their routine diets and not eat banana or milk at bedtime). All patients were prohibited from drinking caffeinated drinks after 5 p.m. and drinking herbal teas close to bedtime because they may interfere with sleep quality. All patients were contacted via telephone over a period of 6 weeks to ascertain their adherence to the study protocols. All patients completed a food consumption record form to ensure compliance with this protocol (Supplementary Table 1). Sociodemographic characteristics of the patients were collected via questionnaire. All patient's anthropometric measurement (height, weight, wait and hip circumferences were measured at the beginning of study. Depression of patients identified by the BECK Depression Scale validated in Turkish.[14] Venous blood sample was taken during daytime and serum BDNF, leptin, and ghrelin concentrations analysed. Study design was shown in Figure 1.

Sleep assessment

Subjective sleep assessment was determined by the Pittsburgh Sleep Quality Index (PSQI) validated in Turkish.[15] This scale assessed sleep quality and disorders in past month. These are subjective sleep quality, sleep time, sleep latency, sleep efficiency, usage of drug for sleeping, sleep disorder and daytime functionality disorder. Furthermore, the objective sleep assessment method, polysomnography (PSG), was used to analyse patients' sleep architecture. The type of sleep disorders was determined by electroencephalogram (EEG) and electrocardiogram (ECG). These are done in the sleep laboratory simultaneously with neurophysical or cardiorespiratory records signalling. Records were then assessed and scored by a neurologist following the American Sleep Medicine Academy criteria.

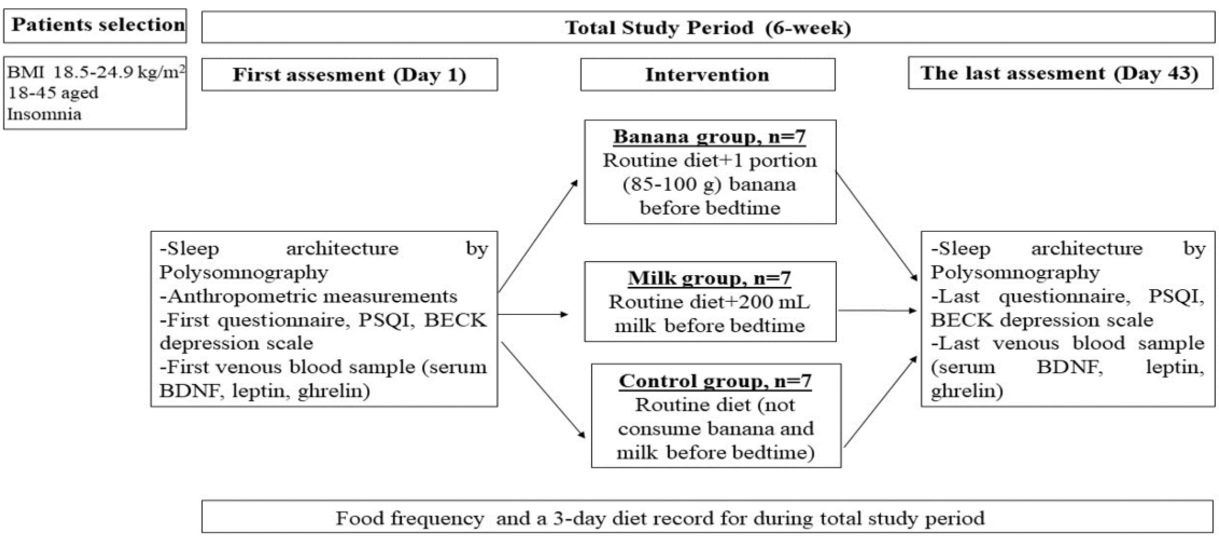


Figure 1. Study design

Statistical analysis

SPSS (Statistical Package for Social Science, version 24; Chicago, IL, USA) was used for statistical analysis of data. Homogeneity of variance, which is a prerequisite for parametric tests, was evaluated using the "Levene" test and normality of the data was tested by Saphiro-Wilk test. If differences between variables are not normally distributed, non-parametric tests were used such as Wilcoxon or Mann Whitney U. Data were distributed normally parametric test was such as Paired t-test used for analysing data. In evaluating the difference between the means of three variables, one-way analysis of variance (ANOVA), which is one of the parametric tests, was used if the data was normally distributed, and Kruskal-Wallis variance test, one of the non-parametric tests, was used if it was not normally distributed. Pearson Correlation Coefficient was used to evaluate the relationship between continuous and normally distributed variables, and Spearman Correlation Coefficient was used to evaluate the relationship between non-normally distributed variables. For repeated tests, the assumption of sphericity was checked with the Mauchly test. Since the assumption of sphericity was not met, Greenhouse Geisser test results and mixed design analysis of variance were used for repeated measurements. The partial eta squared (η^2) was reported as a measure of effect size. All statistical analyses were done with SPSS 24.0 (IBM SPSS Statistics for Windows) statistical package program, and the significance level was accepted as $p<0.05$.

RESULTS

Twenty-one patients with insomnia completed the study without any adverse events. Seventeen (81%) of the patients were women and 4 were (19%) men. 57.1% of the patients were between the ages of 18-30, and 42.9% were between the ages of 31-45 ($p>0.05$). 85.7% of the patients in the banana and control groups were women and 14.3% were men whilst 71.4% of the patients in the milk group were women and 28.6% were men ($p>0.05$). When the age and anthropometric characteristics of the patients were evaluated, it was seen that age, body weight, height, BMI, waist and hip circumference were similar in all three groups ($p>0.05$). Age and anthropometric characteristics of all patients was shown in Table 1.

Subjective sleep quality

As for PSQI scores, the ANOVA revealed a significant Group x time interaction (F=1.461, $p=0.258$) whereas the main effects of Group (F=3.930, $p=0.038$) and time (F=21.791, $p<0.001$) were significant. In post-hoc analyses, a statistically significant difference was found between the banana and control group averages ($p=0.005$) and between the milk and control group averages ($p=0.022$) in terms of the post-intervention PSQI score. Comparison of PSQI and BECK Depression Scale scores between groups and within groups was presented in Table 2.

Objective sleep quality

PSG and actigraphy are the primary methods used in the evaluation of sleep parameters. In this study, the PSG test, was used in the measurement of the sleep architecture of patients with insomnia. Multiple analysis of variance was used in repeated measurements to determine whether there was a difference between the groups' mean total sleep time from PSG test components. As for total sleep time, the ANOVA revealed a nonsignificant group x time interaction (F=0.882, $p=0.431$) and the main effects of group (F=1.803, $p=0.193$) but time (F=5.828, $p=0.027$) were found as significant.

Multiple analysis of variance was used in repeated measurements to determine whether there was a difference between the groups' mean sleep efficiency from PSG test components. As for total sleep efficiency, the ANOVA revealed a nonsignificant group x time interaction (F=0.665, $p=0.527$) and the main effects of group (F=1.235, $p=0.314$) and time (F=3.981, $p=0.061$) were found as nonsignificant.

Multiple analysis of variance was used in repeated measurements to determine whether there was a difference between the groups' mean sleep latency from PSG test components. As for total sleep latency, the ANOVA revealed a nonsignificant group x time interaction (F=0.117, $p=0.349$) and the main effects of group (F=1.868, $p=0.183$), and time (F=3.938, $p=0.063$) were found as nonsignificant. The common effect of factors showing measurements at different times and being in different groups on sleep latency is not significant.

Multiple analysis of variance was used in repeated measurements to determine whether there was a difference between the groups' mean NREM minutes from PSG test components. As for total NREM, the ANOVA revealed a nonsignificant group x time interaction (F=2.555, $p=0.106$) and the main effects of group (F=0.025, $p=0.976$) and time (F=3.707, $p=0.070$) were found as nonsignificant. The common effect of factors showing measurements at different times and being in different groups on NREM is not significant.

Multiple analysis of variance was used in repeated measurements to determine whether there was a difference between the groups' mean NREM minutes from PSG test components. As for total NREM, the ANOVA revealed a nonsignificant group x time interaction (F=3.691, $p=0.071$) and the main effects of group (F=0.068, $p=0.935$), and time (F=2.576, $p=0.104$) were found as nonsignificant. The common effect of factors showing measurements at different times and being in different groups on REM is not significant. Comparison of PSG Test components of all patients by groups was presented in Table 3.

Biochemical parameters

Baseline serum BDNF concentrations of patients in the banana, milk and control groups were 86.1±81.3; 23.7±15.0; 28.4±21.3 pg/mL and 34.8±35.4 pg/mL, 20.3±8.9 pg/mL and 19.5±7.8 pg/mL post-intervention. Multiple analysis of variance was used in repeated measurements to determine whether there was a difference between the groups' mean serum BDNF concentration and biochemical parameters. As for serum BDNF, the ANOVA revealed a nonsignificant group x time interaction (F=2.954, $p=0.078$) and the main effects of group (F=3.150, $p=0.067$) and time (F=5.796, $p=0.027$) were found as significant.

Table 1. Age and anthropometric characteristics of all patients (n=21)

	Banana (n=7)		Milk (n=7)	
	Mean±SD	Min-Max	Mean±SD	Min-Max
Age (year)	27.8±8.3	20.0-42.0	28.1±9.2	18.0-45.0
Weight (kg)	63.0±8.5	56.0-75.0	67.2±12.9	52.0-85.0
Height (cm)	166±6.2	160-174	166±11.4	155-184
BMI (kg/m^2)	22.7±2.4	18.9-25.5	24.0±2.0	20.7-25.3
Waist circumference (cm)	77.0±11.9	63.0-97.0	82.2±11.3	65.5-96.5
Hip circumference (cm)	101±5.3	92.0-108	103±6.7	94.0-112

	Control (n=7)		F/W	*p*
	Mean±SD	Min-Max		
Age (year)	27.1±5.4	20.0-34.0	0.03	0.97
Weight (kg)	57.4±7.6	48.0-72.0	1.72	0.21
Height (cm)	162±4.3	157-170	2.28	0.32
BMI (kg/m^2)	22.0±213	18.7-25.4	2.42	0.30
Waist circumference (cm)	71.9±10.8	63.5-95.0	2.55	0.28
Hip circumference (cm)	98.2±5.5	90.0-105	1.35	0.29

BMI: Body mass index

Table 2. Comparison of PSQI and BECK Depression Scale scores

Scale scores	Baseline	Post- intervention	$^a\eta^2$	p^1	$^b\eta^2$	p^2	$^c\eta^2$	p^3
PSQI score					0.05	0.612	0.46	0.01*
Banana	9.3±2.4	4.7±0.7†	0.63	0.01*				
Milk	8.7±2.6	5.4±2.9§	0.36	0.04*				
Control	10.1±3.1	8.4±1.3$^{\delta}$	0.14	0.22				
BECK score					0.02	0.81	0.07	0.51
Banana	12.3±4.4	5.0±2.1	0.63	0.02*				
Milk	10.3±5.6	7.1±5.5	0.52	0.05				
Control	12.0±7.9	8.0±5.9	0.42	0.12				

PSQI: Pittsburgh Sleep Quality Index; BECK: BECK Depression Scale score
p^1: Comparison of mean value in groups. p^2: Comparison of mean values between groups in baseline. p^3: Comparison of mean values between groups in post-intervention
$^{\dagger}\delta$ between banana and control group
$^{\S}\delta$ between milk and control group
$^a\eta^2$: Within groups. $^b\eta^2$: Baseline condition between groups. $^c\eta^2$: Post-intervention condition between groups
*$p<0.05$

Baseline serum leptin concentrations of patients in the banana, milk and control groups were 0.7±1.5 ng/mL, 0.1±0.1 ng/mL and 0.3±0.3 ng/mL and 0.5±0.79 ng/mL, 0.1±0.14 ng/mL and 0.1±0.13 ng/mL post-intervention. Multiple analysis of variance was used in repeated measurements to determine whether there was a difference between the groups' mean serum leptin concentration and biochemical parameters. As for serum leptin the ANOVA revealed a nonsignificant group x time interaction (F=0.62, p=0.55) and the main effects of group (F=1.05, p=0.37) and time (F=2.38, p=0.14) were found as significant.

Baseline serum ghrelin concentrations of patients in the banana, milk and control groups were 5437±1811 pg/mL, 3693±1785 pg/mL and 3770±2639 pg/mL and 3602±1597 pg/mL, 3526±2166 pg/mL and 3079±1203 pg/mL post- intervention. Multiple analysis of variance was used in repeated measurements to determine whether there was a difference between the groups' mean serum leptin concentrations from biochemical parameters. As for serum leptin the ANOVA revealed a nonsignificant group x time interaction (F=0.78, p=0.48) and the main effects of group (F=1.18 p=0.33) and time (F=2.58 p=0.13) were found as nonsignificant. Comparison of biochemical parameters of all patients by groups was indicated in Table 4.

DISCUSSION

Insomnia is the most common form of sleep disorder. It leads to such a range of health problems such as hypertension, obesity and diabetes. Diet is one of the prevention or treatment factors for insomnia. This clinical study aimed to determine the effects of bedtime banana and milk intake on patients with insomnia. Objective and subjective sleep and biochemical parameters were evaluated at baseline post-intervention. PSQI score was significantly reduced in the milk and banana group post-intervention. Overall, the PSQI score of the milk and banana group was significantly lower than the control group after 6 weeks of intervention. This indicated that 6-weeks bedtime banana and milk intervention improved subjective sleep quality. Therefore, bedtime banana and milk may be associated with improved sleep parameters or sleep quality. Patients who drank honey with milk twice a day for three days showed significantly increased sleep score according to the Richards-Campbell sleep scale when compared to the control group.[16] Another study conducted in the elderly showed a reduction in sleep

Table 3. Comparison of PSG Test components of all patients by groups

PSG Test Components	Banana (n=7)	Milk (n=7)	Control (n=7)	$^{a}\eta^2$	p^1	$^{b}\eta^2$	p^2	$^{c}\eta^2$	p^3	$^{d}\eta^2$	p^4
Total sleep time (min)						0.12	0.25	0.36	0.04*	0.02	0.62
Baseline	204±78.6	161±84.4	263±68.5	0.25	0.07						
Post-intervention	253±71.9	265±82.3	289±68.5	0.03	0.77						
Sleep efficiency (%)						0.20	0.14	0.20	0.13	0.01	0.84
Baseline	52.3±20.8	42.7±19.8	62.5±18.2	0.17	0.20						
Post-intervention	68.4±13.9	63.6±20.2	65.3±25.6	0.01	0.91						
Sleep latency (min)						0.50	0.06	0.09	0.74	0.05	0.87
Baseline	121±71.8	130±114	57.9±51.4	0.08	0.19						
Post-intervention	36.3±34.3	81.7±61.3	55.8±61.8	0.12	0.31						
NREM (%)						0.36	0.18	0.03	0.92	0.54	0.04*
Baseline	98.1±1.5	97.3±2.5	99.8±0.6	0.25	0.04*						
Post-intervention	94.1±5.2	95.5±7.2	92.2±8.9	0.02	0.46						
REM (%)						0.41	0.13	0.03	0.92	0.54	0.04*
Baseline	1.8±1.4	4.5±7.2	0.2±0.6	0.25	0.04*						
Post-intervention	5.9±5.2	2.7±2.4	6.2±5.9	0.11	0.34						

PSG: Polysomnography; NREM:Non-rapid eye movement; REM: Rapid eye movement
p^1: Comparison of mean value between groups. p^2: Comparison of mean values intra groups in banana group. p^3: Comparison of mean values intra groups in milk group. p^4: Comparison of mean values intra groups in control group
$^{a}\eta^2$: Between groups. $^{b}\eta^2$: Intragroup effect size in banana groups. $^{c}\eta^2$: Intragroup effect size in milk groups. $^{d}\eta^2$: Intragroup effect size in control groups
*p<0.05

Table 4. Biochemical parameters of all patients by groups

PSG Test Components	Banana (n=7)	Milk (n=7)	Control (n=7)	$^{a}\eta^2$	p^1	$^{b}\eta^2$	p^2	$^{c}\eta^2$	p^3	$^{d}\eta^2$	p^4
BDNF (pg/mL)						0.14	0.61	0.45	0.09	0.27	0.31
Baseline	86.1±81.3	23.7±15.0	28.4±21.3	1.28	0.12						
Post-intervention	34.8±35.4	20.3±8.9	19.5±7.8	0.03	0.28						
Leptin (ng/mL)						0.37	0.17	0.25	0.35	0.63	0.02*
Baseline	0.7±1.5	0.1±0.1	0.3±0.3	0.19	0.06						
Post-intervention	0.5±0.8	0.1±0.1	0.1±0.1	0.17	0.08						
Ghrelin (pg/mL)						0.09	0.74	0.54	0.04*	0.09	0.74
Baseline	5437±1811	3692±1785	3770±2639	0.14	0.10						
Post-intervention	3602±1597	3526±2166	3079±1203	0.02	0.83						

PSG: Polysomnography
p^1: Comparison of mean value between groups. p^2: Comparison of mean values intra groups in banana group. p^3: Comparison of mean values intra groups in milk group. p^4: Comparison of mean values intra groups in control group
$^{a}\eta^2$: Between groups. $^{b}\eta^2$: Intragroup effect size in banana groups. $^{c}\eta^2$: Intragroup effect size in milk groups. $^{d}\eta^2$: Intragroup effect size in control groups
*p<0.05

disorder in the intervention groups given either one or two bananas daily for 14 days when compared to the control group.[17] On the contrary, Markus et al. (2005) found that evening alpha-lactalbumin intake in healthy subjects with or without sleep complaints induced a 130% increase in Tryptophan: Large Neutral Amino Acids before bedtime but significantly reduced sleepiness.[18]

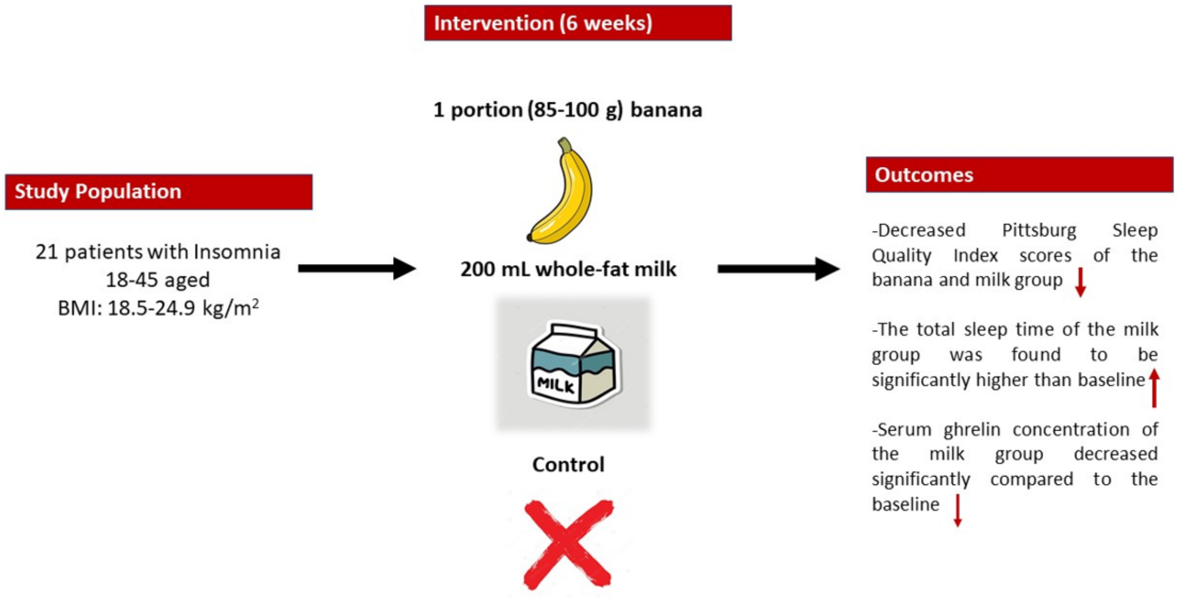
PSG test and actigraphy are the main objective methods used to evaluate sleep quality. In this study, the PSG test was used to evaluate the sleep architecture of patients with insomnia. In the study, no significant difference was found between the total sleep time of the banana, milk and control groups. Total sleep time of all groups were increased after intervention, but only a significant difference was found in the milk group pre- and post-intervention. When the sleep efficiency of the patients was evaluated, all groups showed increased sleep efficiency post-intervention, but no significant difference was found between all groups. Also, there was no significant change in sleep activities before and after intervention in all groups. Similar results were observed in a study conducted by Howatson et al. (2012), whereby Montmorency cherry juice or a placebo drink was offered to 20 patients aged between 18 and 40 for 7 days.[19] The results were evaluated objectively by actigraphy and subjectively by sleep diaries. At the end of the study, according to the actigraphy results, a significant increase in total sleep time, a non-significant decrease in sleep latency, and a non-significant increase in sleep efficiency were detected in the intervention group compared to the control group and pre-intervention.

In our study involving 21 insomnia patients, when examining the sleep latency of individuals, it was observed that the sleep latency decreased more in the banana and milk group compared to the control group. However, there was no statistically significant difference between the groups. In a randomized controlled trial evaluating the effects of an evening milk-based drink on sleep efficiency and memory recall in sleep-deprived Indonesian children, children aged 5-6 years were randomly assigned to three intervention groups including a reference product, a satiety stimulant product, and a relaxant product, in which all were prepared with milk. The study lasted for 6 weeks, during which the children drank two portions of 200 mL of the milk drink per day in the evening. Sleep parameters were monitored using actigraphy and a sleep diary over three consecutive days. At the end of the study, no significant differences were found between the treatment groups in terms of total sleep time, sleep efficiency, or number of awakenings. However, in the group receiving the milk drink consisting of the satiety stimulant product, there was a significant increase in the number of awakenings by the end of the intervention, which was negatively correlated with sleep efficiency.[20]

BDNF is of great importance in regulating food intake and body weight. It is predicted that the increase in BDNF secretion in healthy individuals may increase the entry of leptin into the brain or cells and reduce its serum concentrations. In this study, no significant difference was found between inter-group or intra-group comparisons of banana, milk and control group patients. The reason for not seeing a significant difference in BDNF concentrations compared to baseline may be due to multiple factors. First, it is believed that BDNF concentrations are not solely determined by the amount of BDNF present in platelets, but rather by the platelets' capacity to release it. In the study, analysing the 'ratio between BDNF in serum and whole blood' rather than serum BDNF concentration can more clearly express the BDNF concentration of the patients, as it represents the release of BDNF from platelets.[21] It is also assumed that the venous blood samples taken from the patients in this study were collected during the day rather than in the early hours of the morning. Additionally, some female patients donated blood during their menstrual period, which may also affect BDNF concentration. In a study involving 18 healthy individuals, it was observed that consumption of dark chocolate by patients for 4 weeks did not cause any change in BDNF concentration. Similarly, in another study involving 21 healthy individuals, a decrease in meal frequency over 8 weeks also did not result in any change in BDNF concentration.[22,23] On the contrary, in a study evaluating serum BDNF concentrations among 50 adults with insomnia symptoms and healthy controls, it was observed that individuals experiencing sleep deprivation had significantly lower serum BDNF concentrations compared to healthy individuals with normal sleep patterns, which aligns with findings in the existing literature.[24]

Sleep deprivation activates the sympathetic nervous system and leads to a decrease in leptin concentration.[25] In a study involving children of various ages (3 years, 7 years, late adolescence), sleep deprivation was associated with lower leptin concentrations specifically in late adolescent boys. However, there was no observed relationship between sleep duration and serum leptin concentration at other ages. On the other hand, in a separate study including twenty-one patients with insomnia, no significant difference was found in serum leptin concentrations between groups after a 6-week period of receiving a night meal. However, a significant difference in leptin concentration was detected only in the control group compared to baseline. This significance in the control group could be attributed to some patients failing to adapt to the study protocol or experiencing lifestyle changes over the extended study period. In another study involving 15 healthy men with ideal body weight, spontaneous physical activity was monitored using an accelerometer throughout the entire experiment. Food intake and related hormone levels were assessed during two nights of regular sleep and two nights of sleep deprivation followed by a 15-hour daytime period. It was observed that acute sleep restriction did not affect the participants' ghrelin and leptin concentrations.[26]

It is known that ghrelin concentration can be affected by dietary energy, protein and fat intake as well as weight loss.[27] here are numerous studies in the literature examining the effect of sleep deprivation on ghrelin concentration.[28,29] In a study conducted by Broussard et al. (2016), ghrelin concentration was found to be significantly higher after sleep restriction. Fasting blood leptin, ghrelin and adiponectin concentrations of 44 university students with a BMI over 30 were measured after one night of sleep deprivation in another study. It was found that after sleep deprivation, fasting leptin concentrations were found to



Graphical abstract.

be significantly lower, and ghrelin and adiponectin concentrations were significantly higher.[28] In this study, it was observed that ghrelin concentration of insomnia patients decreased after given banana or milk at bedtime. Serum ghrelin concentrations significant decreased in the milk group post-intervention. Since the half-life of ghrelin is 15-20 min, bananas given as a night meal may have prevented this effect from being directly and significantly reflected in the serum.[30]

Conclusion

Banana and milk are two foods believed to be effective in sleep and relaxation. In this study, the sugar in ripened banana and milk consumed at bedtime help release insulin, drawing larger amino acids into muscle tissue and allowing tryptophan to cross the blood brain barrier; thus, promoting the synthesis of serotonin and melatonin, which may improve sleep parameters. Additionally, both bananas and milk contain tryptophan, further supporting their potential sleep-promoting effects.

This study is the first to experimentally evaluate the role of banana and milk in sleep quality and other sleep components using the PSG test, which is known as the gold standard objective method; hormones involved in sleep and appetite such as BDNF, leptin, and ghrelin were also assessed. Furthermore, the foods provided in the study were given as a night meal, provided just before bedtime. This timing is crucial as it coincides with the onset of melatonin synthesis, which promotes sleep. Many studies in the literature highlight the significance of meals at bedtime and their effects on sleep.

According to the present study, a statistically significant decrease was observed in the PSQI score, which evaluates subjective sleep quality, among patients in the banana and milk group compared to the baseline. According to the PSG test results used to evaluate objective sleep quality, the total sleep duration and REM percentage of the individuals increased significantly at the end of the study, while the NREM percentage decreased significantly. Significant difference was found between individuals' baseline and post-intervention leptin concentrations. Venous blood samples were taken shortly after the consumption of milk or banana in order to evaluate their direct effects and to prevent interference from other foods consumed; this is also to enhance the power of the study and the reliability of the data. However, taking blood samples as a routine before going to bed at night is not sustainable. This study also has its limitations. Banana or milk consumption were based on self-reported food records and patient declaration. In addition, the body weight of patients was not recorded at the end of the study. Further studies may be conducted to determine the relationship between the effects of bedtime eating on sleep deprivation objectively, especially focusing on specific foods such as bananas or milk

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AUTHOR DISCLOSURES

The authors declare that there are no conflicts of interest.

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Supplementary Table 1. Comparison of daily energy and nutrient intake of patients[†]

	Banana (n=7)		Milk (n=7)		Control (n=7)		Test value	*p*
	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max		
Energy (kcal)	1244±336	716-1630	1226±162	991-1410	1218±501	746-2072	0.989	0.99
Carbohydrate (g)	138±37.1	86.6-189	137±15.5	118-162	137±64.3	88.1-250	0.002	0.99
Percentage (%)	44.6±4.4	38.0-50.4	44.8±3.9	40.8-52.3	44.3±3.5	38.3-48.3	0.029	0.97
Protein (g)	45.6±18.3	25.9-80.2	46.9±7.5	31.0-53.8	43.0±17.2	29.3-68.2	0.121	0.89
Percentage (%)	14.5±3.3	12.4-21.9	15.4±1.9	12.5-18.0	14.3±1.5	12.4-15.9	1.527	0.47
Lipid (g)	58.9±17.1	27.3-74.4	53.3±10.6	38.5-68.6	43.7±20.5	9.3-73.4	1.555	0.49
Percentage (%)	43.5±13.5	34.2-73.3	38.9±3.1	34.9-43.8	36.0±14.6	4.0-47.2	0.382	0.83
Fiber (g)	12.9±40	7.1-17.5	12.3±2.6	8.5-14.9	13.1±6.1	7.6-22.5	0.070	0.93
PUFA (g)	10.2±3.32	5.6-14.4	8.7±2.6	5.7-13.7	9.3±3.5	4.6-15.8	0.387	0.69
Cholesterol (mg)	258±162	81.7-476	236.2±75.2	116-350	209±79.3	91.4-348	0.328	0.73
Vit A (mg)	794±478	324-1783	754±357	341-1455	719±354	385-1342	0.208	0.90
Vit E (mg)	7.9±3.5	3.3-12.9	6.6±1.8	4.2-9.1	7.9±3.3	4.5-14.6	0.445	0.66
Vit B-1 (mg)	0.6±0.2	0.3-0.7	0.6±0.1	0.4-0.7	0.6±0.3	0.3-1.0	0.150	0.86
Vit B-2. (mg)	0.9±0.3	0.4-1.1	1.2±0.3	0.52-1.7	0.9±0.4	0.5-1.5	1.967	0.17
Vit B-3 (mg)	9.7±5.3	5.1-20.6	8.9±1.6	5.9-10.9	8.6±2.3	5.8-12.4	0.318	0.85
Vit B-6 (mg)	1.0±0.3	0.5-1.6	0.9±0.2	0.5-1.1	0.8±0.3	0.4-1.4	1.391	0.27
Folate (mg)	167±46.6	93.8-225	191±45.4	106-225	186±74.8	109-319	0.333	0.72
Vit C (mg)	55.7±20.7	28.8-78.7	54.6±21.5	26.6-81.9	52.9±20.3	31.9-84.8	0.033	0.99
Sodium (mg)	1909±642	982-2725	2146±525	1615-3233	2122±687	1318-3027	0.308	0.75
Potassium (mg)	1700±471	1070-2367	1721±358	1145-2177	1519±628	1047-2672	0.349	0.72
Calcium (mg)	385±70.6	268-474	557±143	252-669	420±210	249-791	2.624	0.10
Magnesium (mg)	187±56.9	93.3-245	180±39.8	127-230	165±65.3	106-265	0.349	0.74
Phosphorus (mg)	705±210	375-973	686±341	0.9-955	624±364	172-1161	0.128	0.88
Iron (mg)	7.9±3.6	2.9-13.5	7.3±1.3	5.7-8.6	6.8±2.3	4.4-10.0	0.335	0.72
Zinc (mg)	6.4±1.9	3.2-8.4	7.0±1.2	5.2-8.5	6.6±2.6	4.2-10.7	0.181	0.84

PUFA: Polyunsaturated fatty acid
[†]Nutrient intake acquired from patients' food consumption records taken 3 times a week for a total of 18 days.