Bedtime banana and milk intake on sleep and some biochemical parameters

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ABSTRACT

Background and Objectives: This study aimed to evaluate the effects of milk and banana given as a bedtime 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:** Study was conducted with 21 patients with insomnia who met the inclusion criteria. The patients were divided into 3 parallel groups: banana, milk and control. The intervention group were given at bedtime just 1 portion of banana or just 200 mL of whole-fat milk. Control group did not consume any non-routine food. Baseline and after the study, venous blood samples were taken from the patients to measure brain-derived neurotrophic factor, leptin and ghrelin concentrations, and 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 the 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 the baseline. **Conclusions:** Bedtime milk or banana intake was effective for dealing with insomnia. Foods rich in tryptophan, such as banana and milk, given bedtime, may improve sleep parameters and appetite hormones.

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

INTRODUCTION

Sleep is one of the essential factors, has been providing a crucial role in the maintenance of the circadian system. The increase in sleep quality (low number of awakenings >5 min, less awakening after the onset of sleep, etc.) and sleep duration (7-9 hours/day), thus affecting 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 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 most common form of sleep disorder. It is characterized by one or more of three items: difficulty in initiating or maintaining sleep and/or waking up too early. Spending longer time at work, alcohol consumption, or being overweight are prominent factors associated with shorter sleep duration and indirectly insomnia.[6-8] It brings along so many public health problems, which are common all over the word. For example, insomnia firmly linked with obesity and diabetes and indirectly prevalence of cardiovascular diseases and mortality reciprocally. Furthermore, cognitive dysfunction such as memory problems and difficulty focusing attention 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 higher in tryptophan and melatonin content may improve sleep disorders. The night meal, known as the foods, consumed before bedtime, may have a strong effect on sleep.[12] Especially foods rich in tryptophan given at bedtime would function to release insulin, drawing larger amino acids into muscle tissue and allowing tryptophan to gain access to the transport system to cross the blood-brain barrier and contribute toward the synthesis of serotonin and melatonin. Bananas and milk are tryptophan-rich foods that known to have sleep-inducing effects for many years, but to date, there has been no study that sorts out both of their effects on sleep by objective methods. The aim of the study was to determine the effect of 6-week bedtime banana and milk intervention on sleep quality and also on 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.

MATERIALS AND METHODS

Participants

Patients with insomnia were included in the study between July 2022 and February 2023 in a department of neurology outpatient clinic at one of the university hospitals. Because of sleep complaints, 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 were recruited. Patients' Body Mass Index (BMI) changed from 18.5 kg/m2 to 24.9 kg/m^2 according to WHO classification. Exclusion criteria were; they 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, and were not taking any regular medications (except oral contraceptives) and were nonsmokers. Other exclusion criteria were pregnancy, lactation, extreme physical activity, and allergy to banana or milk. Of the 23 subjects who were accepted to participate present study, two of them dropped out because of not want to continue to study. 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

The study had a controlled-prospective design. The total study duration was 6-weeks with two different intervention groups and a control group. Because of sleep complaints, 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 .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] They willingly choose one of the groups non-randomized; banana group, consume only 1 portion banana (85-100 g) before bedtime, milk group, consume drink only 200 mL whole-fat milk before bedtime, or control group, not exceed 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 may interfere with sleep quality. All patients were controlled for 6 weeks by telephone about whether they obeyed protocols or not. Whole patients filled food consume record form for guaranteed this rule (Supplementary Table 1). Sociodemographic characteristics of the patients were asked by questionnaire. All patient's anthropometric measurement (height, weight, wait and hip circumferences measured at the beginning of study. Depression of patients identified by the BECK depression scale validated in Turkish.[14] A venous blood sample was taken in the daytime and analyzed serum BDNF, leptin, and ghrelin concentrations. Study design was shown in Figure 1.

Sleep assessment

Subjective sleep assessment determined by the Pittsburg Sleep Quality Index (PSQI) validated in Turkish.[15] This scale assesses sleep quality and disorders in the last 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 used in this study, PSG, for analyzing patients' sleep architecture. It is the general name of electroencephalogram (EEG) and electrocardiogram (ECG) record techniques used kind of sleep disorders. It is done in the sleep laboratory simultaneously with neurophsycially or cardiorespiratory records signaling. Records assessed and scored by the master of neurologist by American Sleep Medicine Academy criteria.

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 analyzing data. In evaluating the difference between the means of three variables, ANOVA, one-way analysis of variance, 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 analyzes were analyzed 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 of the patients were (19%) men. 57.1% of the patients in the banana, milk and control groups 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, and 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.

Evaluation of the milk and banana given before bedtime on 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.

Evaluation of the milk and banana given before bedtime on objective sleep quality

PSG and actigraphy are the primary methods used in the evaluation of sleep parameters. In this study, the PSG test, which is one of the objective methods, 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.

Evaluation of the milk and banana given before bedtime on biochemical parameters

Baseline serum BDNF concentrations of patients in the banana, milk and control groups were respectively; 86.1±81.3; 23.7±15.0; 28.4±21.3 pg/mL and post- intervention were found 34.8±35.4 pg/mL, 20.3±8.9 pg/mL and 19.5±7.8 pg/mL. Multiple analysis of variance was used in repeated measurements to determine whether there was a difference between the groups' mean serum BDNF concentration from 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.

Baseline serum leptin concentrations of patients in the banana, milk and control groups were respectively; 0.7±1.5 ng/mL, 0.1±0.1 ng/mL and 0.3±0.3 ng/mL and post- intervention were found 0.5±0.79 ng/mL, 0.1±0.14 ng/mL and 0.1±0.13 ng/mL.Multiple analysis of variance was used in repeated measurements to determine whether there was a difference between the groups' mean serum leptin concentration from biochemical parameters. As for serum leptin the ANOVA revealed a nonsignificant group x time interaction (F=0.624, *p*=0.547) and the main effects of group (F=1.048, *p*=0.371) and time (F=2.375, *p*=0.141) were found as significant.

Baseline serum ghrelin concentrations of patients in the banana, milk and control groups were respectively; 5437.2±1810.8 pg/mL, 3692.6±1784.8 pg/mL ve 3769.7±2639.2 pg/mL and post- intervention were found 3602.2±1596.5 pg/mL, 3525.6±2166.1 pg/mL vs 3078.9±1202.6 pg/mL. 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=0.775, *p*=0.475) and the main effects of group (F=1.178 *p*=0.331) and time (F=2.575 *p*=0.126) 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 kinds of health problems as hypertension, obesity, diabetes etc. Diet is one of the prevention or treatment factors for insomnia. This clinical study aimed to determine bedtime banana and milk intake on patients with insomnia. In this line, objective and subjective sleep and biochemical parameters were evaluated baseline and after the intervention. As a consequence of cross-sectional and prospective study, a significant difference was found between the PSQI score before and after the intervention in the milk and banana group, and the PSQI score of the patients decreased. To sum up, after 6 weeks intervention comparing to baseline, the PSQI score of the milk and banana group was significantly different from the control group. This result indicates that 6-weeks bedtime banana and milk intervention increase subjective sleep quality. Therefore, bedtime banana and milk may be associated with improved sleep parameters or sleep quality. Similarly, in a study conducted on patients with acute coronary syndrome, honey with milk was given to some of the patients twice of day for three days. According to the Richards-Campbell sleep scale, patients who drank honey with milk significantly increased their sleep score compared to the control group.[16] Another study conducted with elderly, patients were divided into 3 groups: consuming one banana/day, two bananas/day for 14 days and control group. This study shows that according to insomnia scale, there was a decrease in sleep disorder in two intervention group.[17] On the contrary, Markus et al. (2005) conducted a study with healthy subjects with or without sleep complaints, slept at the laboratory for 2 nights. Patients' morning performance were evaluated after an evening diet containing either tryptophan-rich alpha-lactalbumin or tryptophan-low placebo protein. Evening alpha-lactalbumin intake induced a 130% increase in Tryptophan: Large Neutral Amino Acids before bedtime and 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, which is one of the objective methods, was used to evaluate the sleep architecture of patients with insomnia. In the study, no significant difference was found between the results of the banana, milk and control groups regarding total sleep time. The total sleep time of the banana, milk and control groups increased after the intervention, but only a significant difference was found between the total sleep time of the patients in the milk group baseline and post-intervention. When the sleep efficiency of the patients was evaluated, an increase was observed in all groups compared to before the intervention, but there was no significant difference between the groups or between the sleep activities of the groups before and after the intervention. Similarly, in a study conducted by Howatson et al. (2012), 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 the beginning. In our study, which included 21 insomnia patients, when the sleep latency of the individuals were examined, it was observed that the sleep latency in the banana and milk group decreased much more than the control group, but there was no significant difference between the groups. In a randomized controlled trial to evaluate whether an evening milk-based drink affected sleep efficiency and memory recall in a group of sleep-deprived Indonesian children (5-6 years old), the children were randomly divided into three intervention groups. The intervention used a reference product, a satiety stimulant product, and a relaxant product. The products are prepared with milk. The intervention lasted for 6 weeks and the children were asked to consume two portions of 200 mL of this milk per day in the evening. Sleep parameters were examined using actigraphy and a sleep diary for three consecutive days. At the end of the study, no difference was found between the treatment groups in total sleep time, sleep efficiency and number of awakenings. In the satiety stimulant product group, the number of awakenings at the end of the intervention increased significantly and was negatively associated 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, where the effects of banana and milk before going to bed were evaluated, 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 of all, it is thought to be due to the fact that BDNF concentrations are not related to the amount of BDNF in platelets, but to the ability of platelets to release it. In the study, instead of serum BDNF concentration, analyzing the 'ratio between BDNF in serum and whole blood', which represents the release of BDNF from platelets, can express the BDNF concentration of the patients more clearly.[21] It is thought that the venous blood sample taken from the patients in this study was taken during the day rather than in the first hours of the day, or that some women patients donated blood during their menstrual period, which may also have an effect on BDNF concentration. In a study involving eighteen healthy individuals, it was observed that consumption of dark chocolate by patients for 4 weeks and in another study, a decrease in meal frequency in 21 healthy individuals for 8 weeks did not cause any change in BNDF 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 with sleep deprivation had significantly lower serum BDNF concentrations compared to healthy sleeping controls, in line with the literature.[24]

Sleep deprivation activates the sympathetic nervous system and paves the way for inhibition of leptin concentration.[25] In a study including children of different ages (3 years, 7 years, late adolescence), sleep deprivation was associated with lower leptin concentrations in late adolescence boys. However, no relationship was found between sleep duration and serum leptin concentration at other ages. On the contrary, in this study, which included twenty-one patients with insomnia, no significant difference was found between the serum leptin concentration of the groups after the night meal given for 6-weeks; However, a significant difference was detected in leptin concentration only in the control group compared to baseline. The reason for this significance in the control group can be attributed to the failure of some patients in the control group to adapt to the study or to changes in the individuals' lives due to the long study period. In another study with 15 healthy men participants with ideal body weight, spontaneous physical activity was recorded with an accelerometer throughout the entire experiment. Food intake and related hormones were assessed during two nights of regular sleep and 2 nights of sleep deprivation followed by a 15-hour daytime period. It was observed that the participants' ghrelin and leptin concentrations were not affected by acute sleep restriction.[26]

It is known that ghrelin concentration changes with dietary energy, protein, fat intake and weight loss.[27] There are many studies in the literature on the effect of sleep deprivation on ghrelin concentration.[28,29] In a study conducted by Broussard et al. (2016), which included 19 healthy men, were divided into normal sleep or sleep-restricted groups. Ghrelin concentration was found to be significantly higher after sleep restriction. Similarly, in a study conducted with forty-four university students with a BMI over 30, fasting blood leptin, ghrelin and adiponectin concentrations were measured after one night of sleep deprivation. At the end of the study, after sleep deprivation, fasting leptin concentrations were found to be significantly lower, and ghrelin and adiponectin concentrations were significantly higher.[28] In this study, it was observed that the ghrelin concentrations of the patients in the banana and milk group, which was given as a bedtime meal to insomnia patients, decreased after the intervention. A significant decrease was found in serum ghrelin concentrations after the intervention was given as a night meal in the milk group. Since the half-life of ghrelin is 15-20 minutes, 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 would function to release insulin, drawing larger amino acids into muscle tissue and allowing tryptophan to gain access to the transport system to cross the blood brain barrier and contribute toward the synthesis of serotonin and melatonin, which may improve sleep parameters. Also they both include tryptophan.

This study is the first to evaluate the role of two nutrients in sleep quality and other components of sleep experimentally, both with the PSG test, which is an objective method known as the gold standard, as well as on hormones involved in the sleep and appetite such as BDNF, leptin and ghrelin. Furthermore, the foods given in the study were given as a night meal, that is, just before going to bed at night. These are the hours when melatonin synthesis begins, which induces sleep, and many studies in the literature mention the importance of the effects of the bedtime meal.

According to the present study, a statistically significant decrease was found in the PSQI score, in which sleep quality was evaluated subjectively, compared to the baseline group of patients in the banana and milk group. According to the PSG test results used in the evaluation of objective sleep quality, at the end of the study, the total sleep duration and REM percentage of the individuals increased significantly, while the NREM percentage decreased significantly. Regarding the role of banana and milk given as a bedtime meal on BDNF, leptin and ghrelin concentrations, a significant difference was found between individuals' baseline and post-intervention leptin concentrations. In order to evaluate the direct effect of milk and banana given to patients as a bedtime meal and to prevent other foods consumed from manipulating this effect, taking a venous blood sample shortly after consumption of banana and milk at night will positively affect the power of the study and the reliability of the data. However, it is not sustainable to take blood samples before going to bed at night in the routine life cycle of individuals. This study has limitations. Banana or milk offered to patients was based on food consumption and frequency records and patient declaration. In addition, the final body weight of the patients was not taken at the end of the study. Further studies may be conducted to determine the relationship between bedtime eating effects on sleep deprivation objectively especially some special foods like bananas or milk.

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CONFLICT OF INTEREST AND FUNDING DISCLOSURE

The authors declare that there are no conflicts of interest.

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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)	166.4±6.2	160.0-174.0	166.4±11.4	155.0-184.0
BMI (kg/m²)	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)	100.7±5.3	92.0-108.0	103.3±6.7	94.0-112.0

	Control (n=7)		F/W	*p*
	Mean±SD	Min-Max		
Age (year)	27.1±5.4	20.0-34.0	0.030	0.970
Weight (kg)	57.4±7.6	48.0-72.0	1.716	0.208
Height (cm)	161.5±4.3	157.0-170.0	2.276	0.321
BMI (kg/m²)	22.0±213.0	18.7-25.4	2.419	0.298
Waist circumference (cm)	71.9±10.8	63.5-95.0	2.549	0.280
Hip circumference (cm)	98.2±5.5	90.0-105.0	1.346	0.285

BMI: Body mass index

Table 2. Comparison of PSQI and BECK Depression Scale scores between groups and within groups

Scale scores	Baseline	Post- intervention	$^{a}\eta^2$	p^1	$^{b}\eta^2$	p^2	$^{c}\eta^2$	p^3
PSQI score								
Banana	9.3±2.4	4.7±0.7†	0.626	0.004*	0.052	0.618	0.456	0.004*
Milk	8.7±2.6	5.4±2.9§	0.359	0.041*				
Control	10.1±3.1	8.4±1.3δ	0.136	0.219				
BECK Depression Scale score					0.023	0.806	0.074	0.503
Banana	12.3±4.4	5.0±2.1	0.634	0.018*				
Milk	10.3±5.6	7.1±5.5	0.521	0.051				
Control	12.0±7.9	8.0±5.9	0.421	0.115				

PSQI: Pittsburg Sleep Quality Index; BECK: xxxx
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
†δ between banana and control group
§δ 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
*$p<0.05$

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)						0.120	0.249	0.356	0.042*	0.023	0.618
Baseline	203.9±78.6	161.3±84.4	262.6±68.5	0.251	0.074						
Post-intervention	253.0±71.9	264.8±82.3	288.6±68.5	0.028	0.772						
Sleep efficiency (%)						0.195	0.140	0.204	0.131	0.005	0.836
Baseline	52.3±20.8	42.7±19.8	62.5±18.2	0.165	0.197						
Post-intervention	68.4±13.9	63.6±20.2	65.3±25.6	0.011	0.907						
Sleep latency (min)						0.497	0.063	0.090	0.735	0.045	0.866
Baseline	121.3±71.8	129.7±114.4	57.9±51.4	0.075	0.188						
Post-intervention	36.3±34.3	81.7±61.3	55.8±61.8	0.121	0.312						
NREM (%)						0.362	0.176	0.028	0.917	0.541	0.043*
Baseline	98.1±1.5	97.3±2.5	99.8±0.6	0.248	0.040*						
Post-intervention	94.1±5.2	95.5±7.2	92.2±8.9	0.024	0.458						
REM (%)						0.407	0.128	0.028	0.917	0.541	0.043*
Baseline	1.8±1.4	4.5±7.2	0.2±0.6	0.251	0.039*						
Post-intervention	5.9±5.2	2.7±2.4	6.2±5.9	0.113	0.341						

PSG: xxxx; NREM: xxxx; REM: xxxx
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)						0.136	0.612	0.452	0.091	0.271	0.310
Baseline	86.1±81.3	23.7±15.0	28.4±21.3	1.275	0.121						
Post-intervention	34.8±35.4	20.3±8.9	19.5±7.8	0.030	0.280						
Leptin (ng/mL)						0.370	0.167	0.252	0.345	0.634	0.018*
Baseline	0.7±1.5	0.1±0.1	0.3±0.3	0.193	0.065						
Post-intervention	0.5±0.8	0.1±0.1	0.1±0.1	0.169	0.080						
Ghrelin (pg/mL)						0.090	0.735	0.542	0.043*	0.090	0.735
Baseline	5437.2±1810.8	3692.6±1784.8	3769.7±2639.2	0.140	0.104						
Post-intervention	3602.2±1596.5	3525.6±2166.1	3078.8±1202.6	0.021	0.826						

PSG: xxx

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

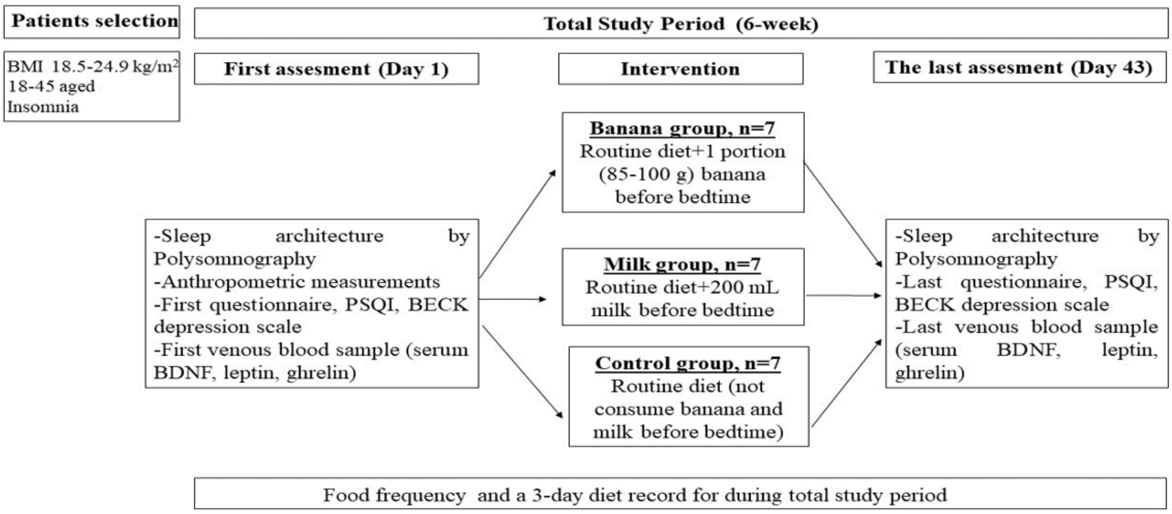
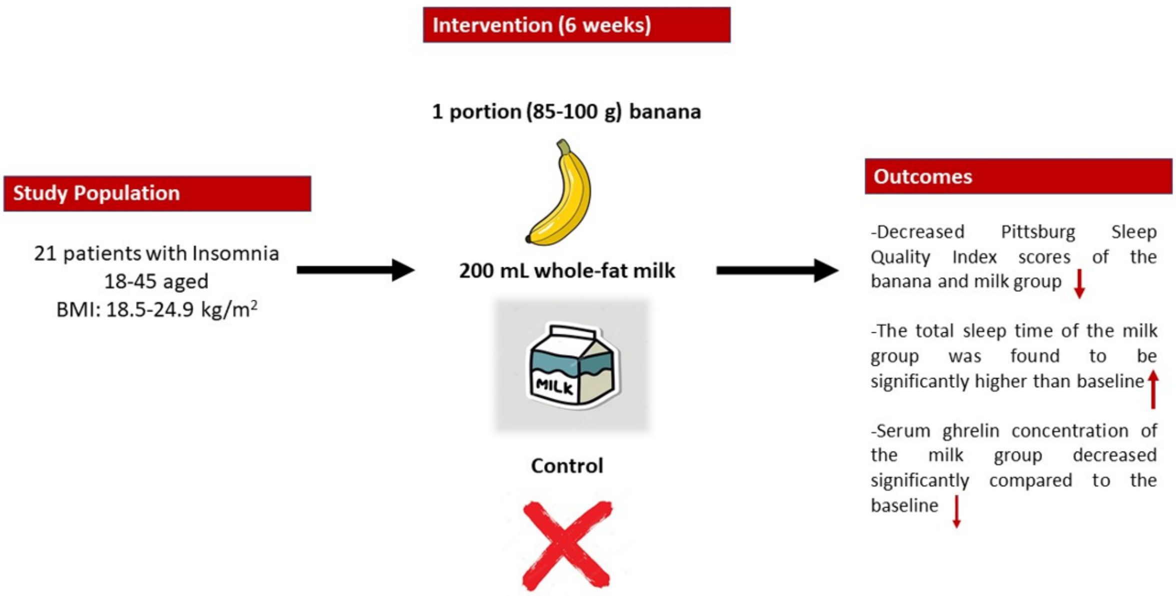


Figure 1. Study design



Graphical abstract.

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

	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)	1243.9±336.3	716.0-1636.0	1225.5±161.7	990.6-1409.6	1217.5±501.1	745.8-2072.0	0.989	0.990
Carbohydrate (g)	137.8±37.1	86.6-189.2	136.6±15.5	118.2-162.0	136.8±64.3	88.1-250.0	0.002	0.998
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	0.971
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	0.887
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	0.466
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	0.489
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	0.826
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	0.932
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	0.685
Cholesterol (mg)	257.5±162.5	81.7-476.4	236.2±75.2	115.6-349.8	208.7±79.3	91.4-348.3	0.328	0.725
Vit A (mg)	794.2±478.1	324.2-1783.0	754.4±357.3	340.9-1455.0	719.4±354.4	385.4-1342.0	0.208	0.901
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	0.658
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	0.862
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	0.170
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	0.853
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	0.274
Folate (mg)	167.4±46.6	93.8-225.1	191.1±45.4	106.4-224.6	186.0±74.8	108.8-319.4	0.333	0.721
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	0.990
Sodium (mg)	1908.9±642.1	982.0-2725.0	2145.6±525.3	1615.0-3233.0	2122.0±686.5	1318.0-3027.0	0.308	0.749
Potassium (mg)	1700.2±471.2	1070.0-2367.0	1720.6±358.1	1145.0-2177.0	1518.6±627.6	1047.0-2672.0	0.349	0.719
Calcium (mg)	385.3±70.6	268.2-474.2	556.9±143.2	251.5-668.7	420.4±200.9	249.4-790.7	2.624	0.100
Magnesium (mg)	187.4±56.9	93.3-244.8	180.2±39.8	126.9-229.8	164.9±65.3	106.4-264.6	0.349	0.740
Phosphorus (mg)	704.8±209.9	374.5-972.5	686.1±340.8	0.9-954.8	623.9±364.3	171.6-1161.0	0.128	0.880
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	0.720
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	0.836

PUFA: Polyunsaturated fatty acid

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