Original Article

Effect of kiwifruit consumption on sleep quality in adults with sleep problems

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Numerous studies have revealed that kiwifruit contains many medicinally useful compounds, among which antioxidants and serotonin may be beneficial in the treatment of the sleep disorders. The aim of this study was to evaluate the effects of kiwifruit on sleep patterns, including sleep onset, duration, and quality. In this study, we applied a free-living, self-controlled diet design. Twenty-four subjects (2 males, 22 females) 20 to 55 years of age consumed 2 kiwifruits 1 hour before bedtime nightly for 4 weeks. The Chinese version of the Pittsburgh Sleep Quality Index (CPSQI), a 3-day sleep diary, and the Actigraph sleep/activity logger watch were used to assess the subjective and objective parameters of sleep quality, including time to bed, time of sleep onset, waking time after sleep onset, time of getting up, total sleep time, and self-reported sleep quality and sleep onset latency, waking time after sleep onset, total sleep time, and sleep efficiency before and after the intervention. After 4 weeks of kiwifruit consumption, the subjective CPSQI score, waking time after sleep onset, and sleep onset latency were significantly decreased (42.4%, 28.9%, and 35.4%, respectively). Total sleep time and sleep efficiency were significantly increased (13.4% and 5.41%, respectively). Kiwifruit consumption may improve sleep onset, duration, and efficiency in adults with self-reported sleep disturbances. Further investigation of the sleep-promoting properties of kiwifruit may be warranted.

Key Words: insomnia, sleep disorders, kiwifruit, antioxidants, sleep quality

INTRODUCTION

Difficulty falling asleep or staying asleep, or disturbed sleep associated with impaired daytime functioning, affects as many as one-third of adults.[1] Chronic insomnia may also lead to an increased risk of depression and chronic use of hypnotic medication.[2] Insomnia is usually treated with stimulus control therapy, relaxation training, and cognitive behavioral therapy, judicious use of hypnotic agents, or with non-pharmacologic remedies.[3] Cognitive behavioral therapy is, however, often difficult and time-consuming to learn, and response to treatment varies widely.[4] And, almost all benzodiazepines and nonbenzodiazepines that are effective for short-term management of sleep disorders produce adverse effects such as daytime sedation, cognitive impairment, dependence and rebound insomnia.[5] Other non-pharmacologic remedies, including antihistamines with sedative effects and alcohol, are ineffective for long-term treatment. Within a few days after antihistamine use, patients may develop tolerance to sedation and adverse effects usually follow within a few days.[6] With alcohol, there is a risk of dependence and exacerbation of other conditions such as gastroesophageal reflux, sleep apnoea, and increased urinary frequency.[7] Consequently, natural treatments that can improve both sleep onset and help patients improve the quality of sleep while improving next-day symptoms over the long term are highly desirable.

Some non-prescription and herbal products such as kava kava and St. John's wort are advertised as sleep-enhancing agents but have not been rigorously studied and there is little evidence that they are effective. Herbal products like Jamaican dogwood and kava kava may also pose potential risks.[7]

Kiwifruits (Actinidiaceae) are native to eastern Asia and their use for treatment of cancer-like diseases, particularly of the digestive tract, dates as far back as 700 BC.[8] Numerous studies have revealed that kiwifruit contains many medicinally useful compounds such as vitamins, carotenoids, and minerals.[9] It is well known that patients with sleep disorders and various neuropsychiatric states exhibit increased levels of oxidative stress.[10] Kiwifruit is rich in antioxidants, vitamins C and E, flavonoids, anthocyanins, and carotenoids, and it contains approximately twice the concentration of serotonin as tomatoes.[11] Serotonin is an end product of L-tryptophan metabolism, which is related to rapid eye movement (REM) sleep and its low levels may cause insomnia.[12,13] Additionally, kiwifruit is rich in folate and insomnia is one of the neuropsychiatric diseases that are secondary to folate deficiency.[14,15] Therefore, it is possible that consuming kiwifruit may be beneficial in

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improving sleep quality in those who have sleep disorders.

This study was designed to evaluate the effects of kiwifruit consumption on various subjective and objective measures of sleep qualities, as measured by actigraphy and a sleep diary, in free-living individuals complaining of sleep disorders.

MATERIALS AND METHODS

This study was conducted at Taipei Medical University between July 2005 and February 2006, and used a free-living, self-controlled diet design. All participants were asked to sign an informed consent form. The protocol was approved by the Human Research Committee of Taipei Medical University.

Forty-four volunteers (aged ≥20 years) who had self-reported sleep disturbances and who had expressed an interest in participating in a dietary intervention study were recruited from the general public and university student body; 44% of participants were college students. Inclusion criteria were self-reported sleep disturbances. A previously validated Chinese version of the Pittsburgh Sleep Quality Index (CPSQI) was used to screen volunteers, and a global CPSQI score of ≥5 was used as the cut-off value indicating poor sleep.[16] Participants were also excluded from the study if they were taking one of the following types of medications at the time of the study: anticonvulsants, antidepressants, beta-blockers, steroids, bronchodilators, stimulants, or decongestants.

Twenty-four subjects, 2 males and 22 females, between 20 and 55 years of age, were enrolled in the study and their data analyzed statistically. All subjects were asked to maintain their normal dietary patterns and activities, but to stop using any hypnotic drugs during the study period. Each subject's height, weight, and body mass index (BMI) were recorded at the initial interview. Medical history was not included.

Instruments used in this study consisted of a self-reported health questionnaire, the CPSQI, and a sleep diary, which were used to assess the subjective parameters of sleep quality, i.e., time to bed, time of sleep onset, waking time after sleep onset, time of getting up, total sleep time, and sleep quality. The self-reported sleep quality was classified as excellent, very good, good, bad, and very bad. Subjects were asked to complete the sleep diary within 30 minutes after awakening. In addition, a Mini-Motionlogger® Actigraph sleep/activity logger wrist watch (Ambulatory Monitoring Inc., Ardsley, NY, USA) was used to objectively assess parameters such as sleep onset latency (SOL, min), waking time after sleep onset (WASO, min) total sleep time (TST, min), and sleep efficiency. Sleep efficiency was defined as the percentage of actual sleep time between sleep onset and final awakening.

All subjects participated in the 5-week, 3-phase study, which included a baseline phase (3 days), a dietary intervention phase (4 weeks), and a washout phase (3 days) (Figure 1). For the baseline and washout phases, subjects were asked to fill out the Chinese version of the Pittsburgh Sleep Quality Index (CPSQI), and to keep a 3-day sleep diary and to wear a sleep/activity logger wrist watch (ActiGraph, Actigraph Company, Pensacola, FL, USA) that assessed and monitored the quality of their sleep and activity.

During the 4-week dietary intervention phase, subjects were asked to consume 2 medium-size kiwifruit 1 hour before bed every night for 4 weeks. Hayward green kiwifruits (*Actinida deliciosa var*) (Zespri Co., Mount Maunganui, New Zealand) were used in this study and the kiwifruits were supplied at an optimum ripeness for consumption.

Continuous data were represented as mean ± standard deviation and Mann-Whitney U test was used to test the difference between the genders. We determined the differences in terms of health problems associated with sleep disorder between the genders by using the Fisher's exact test. The Wilcoxon signed rank test was used to assess differences between pre- and post- kiwifruit intervention results. Objective and subjective measurements were compared using the linear mixed model. All statistics were two-sided, and implemented by SPSS software (version 15.0, SPSS Inc., Chicago, IL). A *p*-value less than 0.05 indicated statistical significance.

RESULTS

Twenty-nine subjects, 5 males and 24 females, 20 to 55 years of age, participated in this study. Of the 29 eligible subjects, 24 ultimately completed the study since data were incomplete for 3 subjects and 2 subjects left the study early. Table 1 shows age and physical characteristics stratified by gender of the final 24 subjects with self-reported sleep problems. There were no significant differences in terms of age, body weight and BMI between male and female subjects ($p>0.05$). However, males were taller than females (1.70±0.04 m vs. 1.59±0.05 m, $p=0.036$). A total of 13 participants had health problems associated with sleep disorder. Among them, 7 participants had sleep disorder due to the stress. Two female partici-

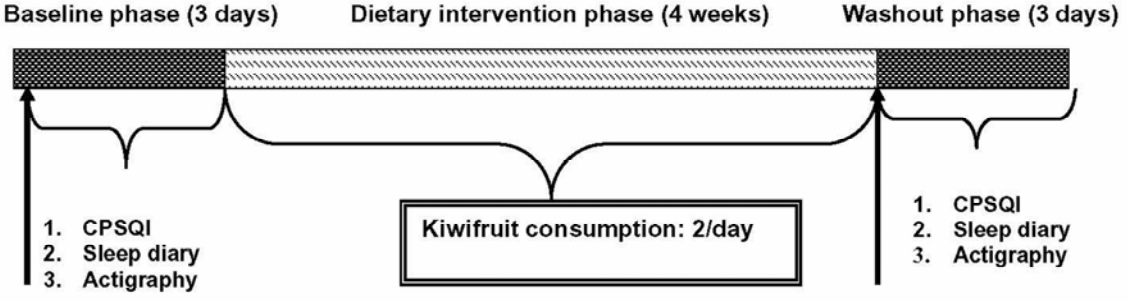

Figure 1. Design of the study

Table 1. Demographics and clinical conditions of participants stratified by gender (n=24)

	Total (n=24)	Male (n=2)	Female (n=22)	*p*-value
Age (years)	34.4±12.9	27.0±5.66	35.1±13.3	0.637
Height (m)	1.60±0.06	1.70±0.04	1.59±0.05	0.036*
Body weight (kg)	54.1±8.03	56.5±3.54	53.9±8.33	0.270
BMI (kg/m2)	21.2±2.69	19.5±0.25	21.2±2.77	0.531
Health problems associated with sleep disorder (number of patients)				
Stress	7	0	7	1.000
Dysmenorrhea	2	0	2	1.000
Flu	2	0	2	1.000
Stomach ache	2	1	1	0.163

*Significant difference using Mann-Whitney U test , *p*-value

pants had experience of sleep disorder due to dysmenorrhea. The rest of four participants had experience of sleep disorder due to either stomach ache or flu.

The differences in measurements before and after kiwifruit intervention are shown in Table 2. There were significant differences in total sleep time (TST) and sleep efficiency measured by the Actigraph sleep/activity logger watch before and after the intervention ($p<0.05$). Statistically significant increases of 16.9% and 2.4% were found for TST and sleep efficiency, respectively. When measured by sleep diary, the CPSQI score, WASO, and SOL, decreased significantly, by 42.4%, ($p<0.001$), 28.9% ($p=0.002$), and 35.4% ($p<0.001$), respectively. In contrast, TST and sleep efficiency significantly increased by 13.4% ($p=0.007$) and 5.41% ($p=0.001$) respectively. Table 3 shows that there were no significant differences in WASO, SOL, TST, or sleep efficiency between objective (Actigraph) and subjective (sleep diary) measurements.

DISCUSSION

The results of this study showed that sleep quality was significantly improved in adult subjects following a 4-week regimen of kiwifruit consumption. Even with the minimal presence of discrepancies between subjective and objective measurements, results substantiated that 4-weeks kiwifruit consumption improved sleep quality in terms of increased total sleep duration and sleep efficiency. Regarding inconsistencies between objective and subjective measurements, we added the Mini-Motionlogger Actigraph sleep/activity logger wrist watch to the objective measurements as a further and more reliable measure of sleep quality than the subjective measurements, which we suspected might not provide sufficiently reliable evidence.

Numerous physiological and pathological processes, including sleep disorders and emotional or physiological stress, increase the bodily concentration of oxidizing substances known as reactive oxygen species (ROS), more

Table 2. Difference in measurements after the 4-week intervention (n=24)

Parameter	Baseline	Post-intervention	*p*-value
Subjective measurements†			
Waking time after sleep onset (min)	18.9±4.31	12.8±3.49	0.002*
Sleep onset latency (min)	34.3±3.86	20.4±3.53	<0.001*
Total sleep time (min)	354.5±17.1	395.3±17.4	0.007*
Sleep efficiency (%)	86.9±1.94	91.2±1.53	0.001*
CPSQI score	10.4±0.69	6.00±0.45	<0.001*
Objective measurements‡			
Waking time after sleep onset (min)	22.2±4.98	16.8±3.41	0.119
Sleep onset latency (min)	16.7±2.80	10.1±1.77	0.086
Total sleep time (min)	361.8±14.9	416.6±16.2	<0.001*
Sleep efficiency (%)	93.9±1.03	95.9±0.67	0.005*

*Significant differences using Wilcoxon signed rank test, $p<0.05$
Values expressed as mean ± standard error
†By sleep diary
‡By Actigraph watch

Table 3. Percent of change from baseline, after 4-week intervention, between subjective and objective measurements (n=24)

Parameter	Subjective measurement†	Objective measurement‡	*p*-value
Waking time after sleep onset (%)	-28.9±11.6	19.2±26.8	0.058
Sleep onset latency (%)	-35.4±7.08	-5.04±16.8	0.070
Total sleep time (%)	13.4±3.78	16.9±3.73	0.254
Sleep efficiency (%)	5.41±1.35	2.38±0.78	0.055

*Significant differences, $p<0.05$. *P*-values are based on linear mixed model
Values expressed as mean ± standard error
†By sleep diary
‡ By Actigraph watch

commonly known as free radicals.[10] These substances are derived from over-expression of inflammatory cytokines and mediators and ultimately lead to depletion of endogenous antioxidants and subsequent compromises in homeostatic mechanisms that involve neurotransmitters.[10] It has been previously reported that there are 85 mg of vitamin C and 1.6 mg vitamin E in 100 g of fresh edible Hayward kiwifruit, accounting for 94% and 11% of Recommended Daily Intake (RDI), respectively.[17] Szeto *et al*.[18] reported that kiwifruit (variety unspecified) contained the highest proportion of ascorbic acid when compared with a large group of fruits, including strawberry, lemon, plum, orange, grapefruit, apple, mandarin orange, mango, grape, banana, pear, pineapple, and Chinese pear.[18] Flavonoids, anthocyanins, and carotenoids have been found in kiwifruit, which can also contribute to its antioxidant capacity.[19] Therefore, the abundance of antioxidants in kiwifruit might be a possible mechanism explaining its effects on improving sleep quality.

The amount, timing and duration of kiwifruit consumption needed in order to study its potential effects on sleep patterns was determined based on the protocols and results of previous studies.[20-25] In two previous trials, subjects consumed 2 kiwifruits (100g each) at a time and researchers noted that this was the amount that most participants would accept.[20,21] In a study of food effects on daylong glucose tolerance, Nilsson *et al.*[22] determined that the time required for blood glucose to peak following a meal is about 60 minutes; and in previous *in vivo* experiments on kiwifruit digestion by four healthy nonatopic volunteers, examination of gastric contents one hour after kiwifruit ingestion was adopted because digestion of the pectin-rich food was complete within that time.[23]These protocols encouraged us to have subjects consume kiwifruits one hour before bedtime so that the fruit would be fully digested and absorbed by the digestive system, allowing effects to be monitored. In most prior studies and clinical trials of kiwifruit consumption, the protocols were designed for 3-4 weeks of kiwifruit consumption. Duttaroy and Jorgenson asked study subjects to consume 2 and 3 kiwifruit per day for successive 28-day periods separated by at least 2-week washout periods in order to examine platelet aggregation and plasma lipids in healthy adults.[24] In a study by Chan *et al*,[25] both patients and controls were given 2 Zespril kiwifruits (one in the morning after breakfast and one in the evening after dinner) for four weeks during which investigators examined the effects of fiber consumption on functional constipation. Even though study objectives varied, the above protocols influenced the adoption in our study protocol of 2 kiwifruits consumed nightly one hour before bedtime for 4 weeks of the study period.

Serotonin is an end product of L-tryptophan metabolism, which is related to REM sleep, and its low levels may cause insomnia.[12,13] Patients with primary insomnia showed a significant decrease of serum tryptophan concentrations and a significant increase in indices of phasic activity of REM sleep (REM density) compared to baseline values.[26] Results of radio-enzymatic serotonin analyses have revealed a high serotonin content in kiwifruit (pulp—edge: 6.8μg/g; pulp—center: 3.0, as per 30 mg of kiwifruit),[11] which might be another possible mechanism contributing to the sleep-improving effects of kiwifruit.

Folate deficiency has been suggested to result in insomnia and restless leg syndrome.[15] Neuropsychiatric diseases secondary to folate deficiency may include dementia, schizophrenia-like syndromes and insomnia. Although folates are abundant in the diet, they are readily destroyed by cooking or processing.[15] Kiwifruit has an advantage in that it is consumed raw and it contains 0.23±0.04 μg/g of total folate, which is almost 80% higher than that in carrot juice and 15% higher than that in orange juice.[13] It is estimated that a single kiwifruit contains approximately one-tenth of the average daily requirement for folate.[17] Thus, it is possible that the folate intake from the raw kiwifruit is also a beneficial mechanism for improving sleep quality.

Results of the present study may lead to prospective studies examining underlying sleep-promoting mechanisms found in "kiwifruit therapy." Nonetheless, this study has limitations and caution should be used in interpolating from these conclusions because the study sample, besides being small, was recruited based on self-reported sleep disorders, rather than from actual clinical diagnoses (i.e., it was unclear whether sleep disorders were comorbid or primary). We had asked whether the participants had experience of sleep disorder due to the health problems during the last month. A total of 13 participants had health problems associated with sleep disorder, which included stress, dysmenorrhea, stomach ache or flu. However, those health problems did not consistently occur. In addition, we were unable to ascertain the degree of subject-expectancy effect arising from a lack of crossover design or placebo (control). A strength of the study was using objective (use of the Actigraph sleep/activity logger watch) and subjective (results of the CPSQI and sleep diaries) means to evaluate specific parameters of sleep quality.

In summary, consumption of 2 kiwifruit nightly 1 hour before bedtime for 4 weeks resulted in improved sleep onset, duration, and efficiency in adults with self-reported sleep disturbances. The results of this study suggest that further research into the sleep-promoting mechanisms of kiwifruit may be warranted.

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AUTHOR DISCLOSURES

The authors have no conflicts of interest to disclose.

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攝取奇異果可以改善成年人之睡眠品質

先前許多研究指出，奇異果(kiwifruit) 含有許多有益健康的成分，其中所含的豐富抗氧化營養素或物質及血清素等，或許對於改善睡眠有幫助。本研究的主要目的，是評估奇異果的攝取是否可以改善睡眠障礙者的睡眠品質，例如睡眠時數及睡眠模式等。共有 24 位(2 位男性、22 位女性) 年齡介於 20-55 歲之自述有睡眠障礙的受試者參與試驗，每位受試者於每夜睡覺前 1 小時食用 2 顆奇異果，為期 4 週。以中文版匹茲堡睡眠品質問卷 (CPSQI)、3 天睡眠日誌及腕動計記錄等工具分別來評估其主觀性與客觀性的睡眠狀況，包括上床時間、入睡時間、睡眠覺醒時間、起床時間、總睡眠時數、睡眠效率、自我睡眠品質評估、整體睡眠品質等。結果顯示，經過 4 週的奇異果介入後，在主觀性的評估方面，受試者的 CPSQI 分數、睡眠覺醒時間與入睡延遲期等均顯著降低，分別降低 42.4%、28.9% 及 35.4%。睡眠總時數與睡眠效率則顯著增加，分別為 13.4% 及 5.41%。因此推測睡前攝取 2 顆奇異果，持續四週對自述有睡眠障礙的成年人而言，可以改善其睡眠品質，但真正的機制及主要可以改善睡眠之成分仍需更多的研究來探討。

關鍵字：失眠、睡眠障礙、奇異果、抗氧化物質、睡眠品質