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Improved Sleep Quality and Work Performance Among Shift Workers Consuming a “Foods with Function Claims” Containing Asparagus Extract

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Abstract : The purpose of this study was to examine whether Foods with Function Claims (FFC) containing asparagus extract effectively improved sleep quality and work performance in shift workers. An intervention study with a before-and-after intervention design was conducted on nurses engaged in two-shift work at a hospital, ingesting a FFC containing asparagus extract. The evaluation period lasted at least two weeks, including three nights shifts during the period. Before and after ingestion, Pittsburgh Sleep Questionnaire Index (PSQI), Utrecht Work Engagement Scale (UWES), Sleep quality (VAS-rated), impaired work functioning, and psychiatric symptoms were evaluated. A diary record, wearing of an activity meter, and a Psychomotor vigilance test were also performed at baseline and after intervention. Data were analyzed by the paired t-test or the Wilcoxon rank sum test. Among 34 participants, 33 completed the study. The results of the primary outcome measures showed significant improvements in PSQI and Sleep Quality in the night of the day after a night shift (PSQI total score: base line 7.41/ post intervention 6.03: $P < 0.001$; sleep quality: base line 4.48/post intervention 6.00: $P < 0.001$). The results of the secondary outcome measures showed significant improvements in UWES and feeling of fatigue. There was also trend of improvement in sleep efficiency and the reaction time. There was no significant improvement in impaired work functioning. This study showed that regular consumption of an FFC containing asparagus extract could improve sleep quality, feeling of fatigue, and work engagement among shift workers. Some caution, however, is needed when interpreting the results because of the before-and-after intervention design without a control group.

Keywords : sleep, shift work, nurse, food products containing asparagus extract, work engagement.

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Introduction

Shift work is a type of employment schedule in which employees are organized into groups, called “shifts”, in which employees work around the clock to provide continuous service [1]. Studies in the United States and Europe have found that between 15% and 30% of adult workers engage in some form of shift work [2]. It is estimated that 5.99 million workers (9.2% of the labor

force) in Japan are on shift schedules, including late-night work [3]. Organizations adopt shift schedules because they improve productivity, such as by permitting equipment to run continuously; such continuous operations are essential in the steel and chemical industries [3]. Moreover, medical facilities (e.g., hospitals) and nursing care providers work shifts because their services must be available around the clock. However, working late-night shifts demands a lifestyle that deviates

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from human norms (i.e., being active during the day and sleeping at night), disrupting the circadian rhythms of those who work them. Such disturbances are known to elevate the risk of developing and exacerbating sleep disorders [4], gastrointestinal problems [5], and cardiovascular disease [6, 7].

Studies continue to report a high prevalence of sleep disorders among shift workers: 2–5% according to the 2005 edition of the International Classification of Sleep Disorders [2]. Disordered sleep can significantly harm occupational health and safety, causing drowsiness while reducing working efficiency and attentiveness [8, 9]. Shift workers are often given “sleep coaching” to help minimize these issues, referring to a variety of advice to improve sleep quality, including taking naps during night shifts and having a consistent bedtime routine [10–12]. Other important considerations include minimizing one’s exposure to noise and brightness during the day and controlling the temperature and humidity of the sleeping environment [10, 11]. Earplugs are a recommended option for noise control; for brightness, one should avoid spending time in the sun after a night shift and use light-blocking curtains or an eye mask in the bedroom [12]. Even though shift workers receive this advice, however, some of these recommendations (such as avoiding sunlight after a night shift, taking naps during night shifts) may simply be infeasible, demonstrating the limits of solely using sleep coaching to improve sleep quality.

Foods with Function Claims (FFC) are foods submitted to the Secretary-General of the Consumer Affairs Agency as products whose labels bear function claims based on scientific evidence, under the responsibility of food business operators [13]. Often labeled as such, food products containing asparagus extract are believed to effectively improve sleep quality [14], and, reportedly, can induce the expression of heat shock protein 70 (HSP70) [15], which is known to protect cells by modifying other proteins that have been partially denatured by thermal or oxidative stress, and appears to be associated with sleep and the circadian rhythms. In animal experiments, HSP70 has been implicated in slow-wave sleep, a crucial component of deep sleep [16, 17]. One interventional study, hypothesizing that HSP70 promotes good sleep by helping the body to recover from damage owing to sleep loss or stress, re-

ported that foods containing asparagus extract (ONR-8) re-synchronized delayed sleep–wake cycles, and also improved sleep quality and alertness on awakening at the start of the working week among individuals with so-called “social jetlag” i.e., one’s get up time shifting later because of sleeping for long hours on weekends to clear sleep debt from weekdays [18].

No research, however, has been reported on the effects of any FFCs containing asparagus extract on the sleep quality and sleep–wake cycles of shift workers. This study examines the effects of one such food product on sleep quality, sleep–wake rhythm, and work performance among shift workers.

The objective of this study was to verify whether an FFC containing asparagus extract would effectively improve sleep quality among shift workers. We also studied the effects of the intake of an FFC containing asparagus extract on factors that affect work performance. These findings will serve as useful reference information when planning measures to improve sleep quality among shift workers.

Methods

Study design

This study employed a before-and-after intervention design, and examined sleep as well as factors affecting work performance during the baseline and post-intervention periods. The overall study design is shown in Figure 1. The two periods were set to include three nights shifts, and lasted for more than two weeks. The participants began to take the test food once they had completed their baseline assessment; the post-intervention period began after they started consuming the test food regularly for two weeks. The participants were required to complete a questionnaire to evaluate subjective measures at the end of each period, on their days off after night shifts. Several objective measures were collected as well, including reaction time and activity meter-based sleep data. The participants also kept a diary during both the baseline and post-intervention periods. They also watched a sleep coaching video before the study began, and were instructed to not greatly alter their normal lifestyle during the period in which they would be consuming the test food. This study was conducted from September to Decem-

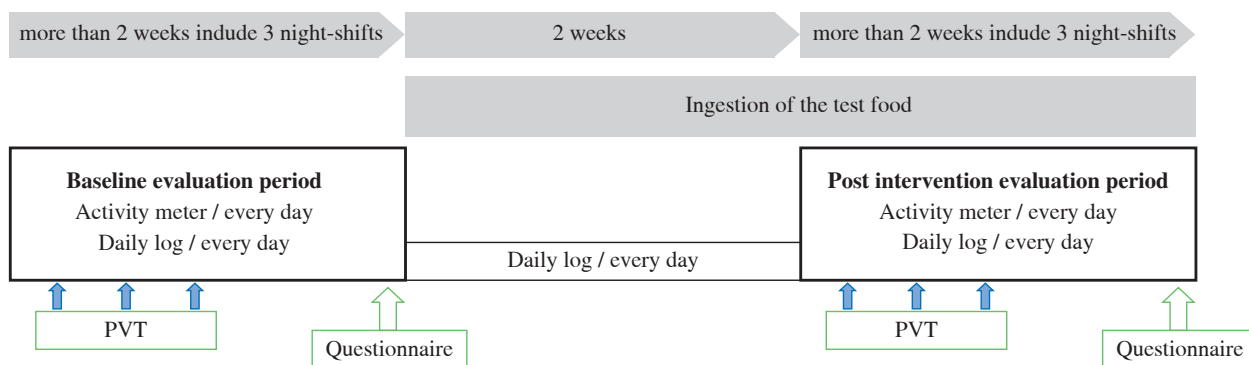


Figure 1. Study design. PVT: psychomotor vigilance test

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Test food

Kenja-no-Kaimin (Suimin Rhythm Support) (English: The Wise Man's Sleep Solution) -- an FFC produced by Otsuka Pharmaceutical Co., Ltd. (Tokyo, Japan), that contains asparagus extract -- was utilized as the test food. Participants ingested one packet (3 g) per day before main sleep without interruption for more than four weeks.

Participants

We recruited nurses of the University Hospital (University of Occupational and Environmental Health). The inclusion criteria were nurses engaged in shift work and having sleep problems. Their shifts include 4–5 night shifts per month and 7–11 day shifts, with at least 1 day off after each night shift. The day shift was from 8:15 to 17:00 (break time was 45 minutes), and the night shift was from 16:15 to 9:15 (break time was 75 minutes). We outlined the research content at a nurse meeting, and then we held 17 study briefings to explain this study to the applicants, and distributed a questionnaire, which included items such as sex and age, years of experience as a nurse, years of shift work, whether or not one was aware of sleep problems (five-point-scale), use of medication, and food allergies. Exclusion criteria were age < 20, currently receiving treatment for a sleep disorder, other conditions that could affect sleep patterns (depression, sleep apnea,

restless legs syndrome, narcolepsy, alcoholism), or living with preschoolers. Participants received tokens worth 30,000 yen as an honorarium for participation.

Ethical considerations

This study was conducted in accordance with the Helsinki Declaration, and with the approval of the UOEH Ethics Committee (accession no: 301028, UMIN ID: UMIN000034109). The recruitment phase commenced after ethical approval was granted. The applicants were given explanations, verbally and in writing, about the significance, purpose, and method of the study, as well as any potential disadvantages to which they would be exposed, and information on risks and safety. Participation was completely voluntary. No one suffered a disadvantage if they did not participate or if they quit during the trial. Participants were enrolled if they provided written informed consent after the full explanation.

Measures

- 1) Primary outcome measures / Sleep
 - a) Pittsburgh Sleep Quality Index (PSQI)

Participants were administered a questionnaire at the end of the baseline and post-intervention periods, in which they rated their sleep quality using the PSQI, a 19-item self-report questionnaire that measures sleep quality during the previous month to discriminate between good and poor sleepers. There is cut-off point; sum scores above 5 indicate a poor sleep quality [19, 20]. The PSQI is the sum of the seven components of subjective sleep

quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The total possible score is 21 points, from 0 to 3 points \times 7 items.

b) Sleep quality (visual analog scale (VAS)-rated)

The participants were administered a questionnaire at the end of the baseline and post-intervention periods, in which they rated their sleep quality using a VAS. This item read, "How was the quality of your sleep last night?" followed by a 10 cm horizontal line anchored by the words "very poor" at the left end and "very good" at the right end. Sleep quality was recorded as the distance (cm) from the left end (0 cm) to the location marked by the participant, rounded to the first decimal place. It had a maximum of 10 points in 1-point increments.

2) Secondary outcome measures: Sleep and Factors that affect sleep and work performance

c) Activity meter (Sleep efficiency, Get up time)

The participants were asked to wear an accelerometer-based activity meter, (FS760, ACOS.CO.LTD, Nagayo, Japan), with established validity [21] at the baseline and post-intervention periods, with the intention of measuring their activity levels. The participants regularly recorded the approximate timing of their sleep (i.e., from when to when), as well as when they put on and took off the device.

Several indexes were determined during wearing periods for the participants' major sleep episodes following a day shift, based on the accelerometer data and diary entries: bedtime, sleep time, wake time, and get up time. Sleep efficiency (%) was calculated as follows: $[(\text{sleep offset time} - \text{sleep onset time}) / \text{get up time} - \text{bedtime}] \times 100$. The average of the readings on corresponding days in each period was adopted for analysis. Data were omitted if the automatic readings of the accelerometer differed by more than 2 hours from the times the participants recorded in their diary (not including cases where the automatic analysis settings were configured by the research staff).

Get up time was analyzed on the days off following a night shift during the period when the participant was wearing the activity meter, utilizing its records for "out-of-bed time". Get up time was converted to

an (arbitrary) ratio, calculated by dividing the hour by 2,400 (for example, a get up time of 6 o'clock would equate to $600 / 2,400 = 0.25$). The average of the readings on corresponding days in each period was adopted for analysis. Data were omitted if the automatic readings differed by more than 2 hours from the times the participants recorded in their diary log (including cases where the automatic analysis settings were configured by the research staff).

d) Psychomotor vigilance test (PVT) (Reaction time test, delayed reactions)

We adopted the PVT, which is used as a performance indicator. The participants took a 3-min PVT on a day shift day while seated and before starting work, using a smartphone application ("sleep-2-peak reaction time" [22]). We lent smartphones to the participants for the study period. During each session, average reaction time was calculated after excluding unusually delayed reactions (≥ 500 ms); delayed reactions were counted separately. Reaction time and delayed reaction counts were averaged for the participants who completed this test more than two times during both the baseline and post-intervention periods.

e) Feeling of fatigue (VAS-rated)

Participants were asked to assess fatigue feeling at the end of baseline and post-intervention periods, in which they rated their fatigue feeling using VAS. This item read, "Please mark the line below at the location that best represents the level of fatigue you're feeling at this moment, based on the statements to the left and right." On the right end (10 cm) was written, "I feel the best I've ever felt, not tired at all," and on the left end, "I feel the worst I've ever felt, so exhausted that I can't do anything at all." Feeling of fatigue was recorded as the distance (cm) from the left end (0 cm) to the location marked by the participant, rounded to the first decimal place. There was a maximum of 10 points in 1-point increments.

f) Work Engagement

The participants were administered a questionnaire at the end of the baseline and post-intervention periods, in which they rated their work engagement. Work engagement is defined as a positive, fulfilling,

work-related state of mind that is characterized by vigor, dedication, and absorption [23, 24]. A shortened version of the Utrecht Work Engagement Scale (UWES) was used to assess positive mental status affecting performance. The UWES consists of 3 components (vigor, dedication, and absorption), with one component having 3 questions, 0–6 points. The sum score ranges from 0 to 54, with higher scores indicating higher work engagement.

g) Work Functioning Impairment Scale (WFun)

The participants were administered a questionnaire at the end of the baseline and post-intervention periods, in which they rated their work disability. The WFun, a valid and reliable instrument for evaluating disability to function at work [25], consists of 7 items (e.g. I have had trouble thinking clearly), using a five-level scale: 1 = 'not at all', 2 = 'one or more days a month', 3 = 'about one day a week', 4 = 'two or more days a week', and 5 = 'almost every day'. The sum of the scores ranges from 7 to 35, with higher scores indicating greater impairment of work functioning.

h) Kessler Psychological Distress Scale (K-6)

The participants were administered a questionnaire at the end of the baseline and post-intervention periods, in which they rated their negative mental status. The K-6 was used to assess negative mental status affecting performance, which is viable for the assessment of psychological distress over a 30-day interval [26, 27]. The total is 24 points from 0 to 4 points \times 6 items.

Statistical method

The analysis of the questionnaire to evaluate subjective items excluded those who reported in the daily log that they had had bad physical condition (fever, pain and allergic symptoms not caused by test food intake) presumed to be unrelated to test food intake. The PVT and activity meter were analyzed for subjects who had at least two data both before and after each intervention. Those who did not conduct PVT before starting work on a day shift were excluded. If the activity meter get up time was excluded from the analysis if it differed from the daily log by more than 2 hours.

All data are shown as mean \pm standard deviation. PSQI total score, Sleep efficiency and PVT reaction

time were analyzed by paired t-tests, and confirmed the equal variances by Levene's test. Wilcoxon rank sum test was performed for UWES total score and number of delayed reactions of PVT when homoscedasticity could not be confirmed. IBM SPSS Statistics v. 24 (IBM Corp., Armonk, New York) was used for analysis: $P < 0.05$ was considered to indicate significant differences. We adopted 0.0125 (0.05/4, which 4 is the number of comparisons) as the statistical significance-level for the primary outcome, after Bonferroni correction to avoid the problem of multiple comparisons. The statistical significance-level for the secondary outcome was 0.05.

Results

Thirty-four participants (27 female) were recruited and started the study, but one woman withdrew. The participants' characteristics are shown in Table 1. The average number of years of shift work, including night shift, was 9.8 years (SD: 6.3). When the mean score of PSQI at baseline was 7.41 (SD: 1.86), the participants were considered to have a non-chronic yet moderately poor sleep problem. Compared to the average of female workers in previous studies [24–28], the work engagement scores were lower, while the WFun and K-6 values were about the same.

The sample sizes for each analysis after excluding unsuitable data were as follows: questionnaires, $N = 29$ (excluded cases, missing data: 2, bad physical condition: 2); reaction time, $N = 22$ (excluded cases, miss-

Table 1. Participant characteristics

Item	Mean	SD	N	%
Age	34.3	\pm 8.5		
Sex				
Female			27	78.7
Male			7	21.2
Nursing Experience (years)	10.8	\pm 8.0		
Experience working in shift, including night shifts (years)	9.8	\pm 6.3		
Sleep Problems				
(1: very much, 2: much, 3: neither, 4: not very, 5: not at all)	1.76	\pm 0.43		

SD: standard deviation

ing data: 9, bad physical condition: 2); sleep efficiency (activity meter), N = 16 (excluded cases, missing data: 15, bad physical condition: 2); and get up time (activity meter), N = 19 (excluded cases, missing data: 12, bad physical condition: 2). No adverse events occurring in the study period appeared to be linked to the test food. The results are shown in Table 2.

Marked improvement was observed in the primary outcome. The PSQI total scores were significantly lower in the post-intervention period than at the baseline period (mean \pm SD: base line 7.41 ± 1.86 ; post intervention 6.03 ± 2.34 ; $P < 0.001$), and improvements were observed in 6 of the 7 PSQI components (sleep quality, sleep onset latency, sleep duration, sleep ef-

iciency, sleep disturbance, daytime dysfunction). There were significant improvements in sleep quality measured by VAS, especially on the nights of the day after night shift.

Some secondary outcomes showed improvement while some did not. Sleep efficiency measured by an activity meter improved by 3 points, although not significantly (mean \pm SD: base line 79.73 ± 8.04 /post intervention 82.08 ± 7.53 ; $P = 0.063$). The participants tended to rise later on days off after leaving a night shift. Reaction time tended to be slightly quicker in the post-intervention period than at the baseline period (mean \pm SD: base line 0.29 ± 0.07 /post intervention 0.28 ± 0.05 ; $P = 0.072$). Delayed reactions were ob-

Table 2. Main outcome and secondary outcome at baseline and intervention period

	N	Baseline		post-intervention		P-value*
		Mean	SD	Mean	SD	
Primary Outcome						
PSQI	29					
Total score**		7.41 \pm 1.86		6.03 \pm 2.34		<0.001
Sleep quality		1.69 \pm 0.54		1.31 \pm 0.47		
Sleep onset latency		1.66 \pm 0.94		1.28 \pm 1.74		
Sleep duration		2.00 \pm 0.38		1.72 \pm 0.53		
Sleep efficiency		0.34 \pm 0.55		0.31 \pm 0.54		
Sleep disturbance		0.79 \pm 0.41		0.69 \pm 0.47		
Sleeping medication use		0.07 \pm 0.37		0.07 \pm 0.37		
Daytime dysfunction		0.86 \pm 0.74		0.66 \pm 0.67		
Sleep Quality (VAS)						
night of work day on day shift**	29	4.10 \pm 1.61		5.45 \pm 1.72		0.003
night of the day after night shift**	29	4.48 \pm 1.84		6.00 \pm 1.46		<0.001
night of day off; the next day after the day after night shift**	29	4.48 \pm 1.60		5.62 \pm 1.78		<0.001
Secondary Outcome						
Activity meter						
Sleep efficiency**	16	79.73 \pm 8.04		82.08 \pm 7.53		0.063
Get up time**	19	0.34 \pm 0.05		0.37 \pm 0.08		0.057
PVT						
Reaction time (sec)**	22	0.29 \pm 0.07		0.28 \pm 0.05		0.072
Number of delayed reactions***	22	1.31 \pm 1.67		0.64 \pm 0.81		0.005
Feeling of Fatigue**	29	5.83 \pm 1.58		4.31 \pm 1.61		0.003
UWES***						
	29	20.10 \pm 9.99		23.21 \pm 10.83		0.008
		6.00 \pm 3.33		7.59 \pm 3.68		
		8.00 \pm 3.30		8.69 \pm 3.82		
		6.10 \pm 4.17		6.93 \pm 4.02		
WFun**	29	14.10 \pm 3.63		13.17 \pm 3.86		0.484
K-6**	29	5.14 \pm 4.58		4.31 \pm 5.44		0.172

*: a level of statistical significance of primary outcome after Bonferroni correction was < 0.0125 , a level of statistical significance of secondary outcome was < 0.05 , **: Paired- t-test, ***: Wilcoxon rank sum test, SD: standard deviation, PSQI: Pittsburgh Sleep Quality Index, VAS: visual analog scale, UWES: Utrecht Work Engagement Scale, PVT: psychomotor vigilance test, WFun: Work Functioning Impairment Scale, K-6: Kessler 6 scale.

served less frequently during the post-intervention period than at the baseline period (mean \pm SD: base line 1.31 ± 1.67 /post intervention 0.64 ± 0.81 ; $P = 0.005$).

Significant improvements were observed in the UWES work engagement score (mean \pm SD: base line 20.10 ± 9.99 /post intervention 23.21 ± 10.83 ; $P = 0.008$). Feeling of fatigue ratings were significantly lower in the post-intervention period when compared with the baseline period (mean \pm SD: base line 5.83 ± 1.58 /post intervention 4.31 ± 1.61 ; $P = 0.003$). No great changes were observed in WFun and K-6 values.

Discussion

This study sought to verify the effects of an FFC that contains asparagus extract on the sleep quality and sleep-wake cycles of shift workers. We found significant improvement in PSQI total scores as the primary outcome.

In a previous study in which cognitive-behavioral therapy for insomnia intervention was conducted for shift workers with sleep disorders, PSQI scores improved by about 20% [10]. The improvement in PQSI scores in the present study was similar to the previous study. Sleep efficacy measurement using an activity meter, which was measured as an objective item of sleep, showed a slight tendency for improvement, but with no significance. Only a few papers have shown that objective sleep efficiency is effective, even in established CBT (Cognitive Behavioral Therapy) [29]. A Finnish study of CBT-I on shift workers with insomnia found no objective improvement in sleep efficiency [11]. On the other hand, a sleep training conducted in Germany for college students with sleep problems reported a slight tendency for improvement in sleep efficiency of 4.2% ($P = 0.25$) [30]. In the present study, the improvement of sleep efficiency was 2.9% ($P = 0.063$), which was weak; this improvement may have contributed to subjective improvement in sleep quality. It is also worth noting that the sleep quality as measured by VAS improved in all of the shift patterns. The nurses also tended to rise later on days off after a night shift in the post-intervention period, presumably because of better sleep habits allowing them to sleep longer and therefore wake up later.

Some of the factors that affect labor productivity, the

secondary outcomes of this study, showed improvements, and some did not. Significant improvements were observed in UWES and Number of delayed reactions of PVT. Vigor increased the most out of the three components assessed, paralleled by work engagement. The work engagement of the participant's baseline data was lower than that of the entirety of Japan shown in previous studies, so it may have been more susceptible to showing improvement [27, 28]. Previous research has reported positive associations between sleep quality and work engagement, though their study design precluded drawing inferences about causality or long-term consistency [31, 32]. Improved sleep quality may improve wakefulness in the morning, relieve the feeling of fatigue, and promote vigor (e.g., the item, "At my work, I feel bursting with energy") to improve work engagement. On the other hand, this intervention did not produce any improvements in the WFun or K-6 score, with WFun evaluating impaired work functioning and the K-6 screening for depression and anxiety. We expected mild improvements in this study since previous research has found that work functioning is affected by sleep behaviors [32] and identified links between sleep deprivation and mental illnesses such as depression and anxiety [33, 34]. This may be because the participants had only mild sleep problems and had no problems with work dysfunction or mental symptoms [25, 27].

One strength of our study is that sleep was evaluated not only by self-report questionnaires, but also by objective activity meters. We observed an improvement in sleep efficiency, although it was not significant. An improvement of conventional significance might emerge if the tests were run again with a larger sample.

There are some limitations to this study. It lacked a control group, and the small sample size severely hindered the interpretation of the results. We could not remove the effects of regression to the mean, social desirability bias, and recall bias. In addition, participants were recruited from a single hospital, and most of them were women. The exclusion criteria were those who were being treated for a sleep disorder, but one participant was taking sleeping medication on an irregular basis. Additional information that may affect sleep such as caffeine and alcohol intake and care of family members living together were not collected,

which may hinder the interpretation and transferability of the results. Finally, we performed the sleep evaluation by measuring with an activity meter, and we were not able to evaluate the effect on sleep depth. Future research will require a control group and further discussions regarding the implications considering the findings.

Conclusion

This study showed an FFC containing asparagus extract regular consumption might improve sleep quality, feeling of fatigue, and work engagement among shift workers.

If shift workers cannot implement sleep guidance recommendations, taking an FFC that contains asparagus extract may be one of the options to improve sleep quality. Further research is needed to expand the generalization of these results.

Conflicts of Interest

This study was conducted with research funding provided by Otsuka Pharmaceutical Co., Ltd.

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