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ORIGINAL ARTICLE

Association between sleep and fatigue in nurses who are engaged in 16 h night shifts in Japan: Assessment using actigraphy

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Abstract

Aim: To determine the association between sleep and fatigue in nurses who are working in a two-shift system, including 16 h night shifts.

Methods: Sixty-one nurses were assessed on their sleeping and napping over 9 days, using actigraphy and a sleep diary. Work-related feelings of fatigue were measured by using the "Jikaku-sho shirabe" questionnaire and the Cumulative Fatigue Symptoms Index.

Results: The main night-time sleep started after 00:00 hours in half of the participants and the average start and end times were significantly delayed among the participants in their 20s, compared to those in their 40s . Although ~90% of the participants napped during and/or after a night shift, only 50.8% napped for >2 h during their shift and 32.8% napped in the morning after a night shift. In the high-fatigue group, significantly more nurses went to sleep after 00:25 hours than before 00:26 hours the night after a night shift. Furthermore, those nurses who napped for >2 h during their night shift exhibited a significantly lower rate of some cumulative fatigue symptoms, compared to those who did not. In addition, a combination of napping in the morning after a night shift and beginning the following night-time sleep before 00:26 hours were associated with a significant decrease in fatigue symptoms.

Conclusions: Naps at an appropriate time and of an appropriate duration, along with the practice of beginning the night-time sleep early after a night shift, might relieve cumulative mental fatigue in nurses who are working 16 h night shifts.

Key words: actigraphy, fatigue, nurses, shift work, sleep.

INTRODUCTION

Shift work is necessary for nurses to provide 24 h on-site patient care. Night-shift workers are prone to sleep deprivation, misalignment of circadian rhythms, and subsequent sleepiness and sleep-related performance deficits. In Europe and the USA, a pattern of two 12–13 h shifts per day is becoming common in many hospitals to reduce shift-to-shift handovers, staffing overlap, and costs, and to satisfy nurses' need for a work–life balance. However, it has been noted that there are risks that are associated with 12 h shifts: medical errors (Griffiths *et al.*, 2014; Rogers *et al.*, 2004; Scott, Rogers, Hwang, & Zhang, 2007), fatigue and performance degradation (Geiger-Brown *et al.*, 2012; Wilson *et al.*, 2017), reduced sleep time and sleep efficiency (Rhéaume & Mullen, 2018), an increase in the risk of drowsy driving accidents (Lee *et al.*, 2016; Scott *et al.*, 2007), and a risk of burnout and job dissatisfaction (Dall'Ora, Griffiths, Ball, Simon, & Aiken, 2015; Stimpfel, Sloane, & Aiken, 2012).

In Japan, since around 2000, the two-shift system has been gradually replacing the traditional three-shift system: 55.1% of wards that are using the two-shift system

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have their nurses work a long night shift of >16 h (Japan Federation of Medical Workers' Unions, 2016). This working pattern, with a 16 h night shift, is becoming more common as a result of its several advantages: nurses need to work fewer night shifts, meaning that their circadian rhythm tends to not be as disrupted (Takahashi *et al.*, 1999); their lifestyle is more balanced (Ichikawa, 1998); the two-shift system is preferred by young nurses (Hara, 2009); and a nap during each night shift is guaranteed. In contrast, nurse fatigue and drowsiness are increased by long night shifts (Matsumoto *et al.*, 2008) and changing to 16 h night shifts did not improve the content of daily activities (Matsumoto, 2015). Given these working conditions, the Japanese Nursing Association published a set of "Guidelines on night shift and shift work for nurses" (Japanese Nursing Association, 2013), hereafter referred to as the "guidelines". These guidelines recommend that nurses adhere to the following pattern of napping: take a nap for ~2 h before beginning a night shift; take a nap for >2 h during the night shift; and go to sleep at home as early as possible the night after a night shift, but take a nap during the day for ~2 h to avoid disturbing the pattern of nocturnal sleep.

Napping is effective in reducing drowsiness and in preventing attention and performance deterioration (Geiger-Brown *et al.*, 2016; Lovato, Lack, Ferguson, & Tremaine, 2009; Smith, Kilby, Jorgensen, & Douglas, 2007). Furthermore, taking a nap before and after night shifts has been shown to reduce nurses' fatigue (Kayahara & Taniguchi, 2014). Fatigue was lower after night-shift work in the nurses who woke up at the same time as on regular days in the morning than those who woke up later on the night-shift work morning (Miyazaki & Hosona, 2013).

These facts suggest that fatigue among shift-working nurses is related to their napping habits and wake-up time. However, most of the above-mentioned studies used questionnaires; there are few studies that objectively evaluated nurses' sleep. Furthermore, following publication of the guidelines, there has been no report verifying whether nurses follow the napping pattern that has been suggested or investigating the fatigue-mitigating effects of napping.

Therefore, in this study, sleep data that were collected by using actigraphy from nurses working 16 h night shifts was evaluated and the relationship between sleep and fatigue was clarified. These findings could serve as fundamental data regarding nurses' fatigue levels. It was hypothesized that fatigue would be higher when nurses do not take a nap according to the guidelines and the starting time of the main sleep are late.

METHODS

Study aim

To determine an association between sleep, including napping, and fatigue that was measured by using an actigraph in nurses working on a two-shift system with 16 h night shifts in Japan.

Definition of operational terms

Two-shift system: day shift from 08:30 hours to 17:00 hours; night shift from 16:30 hours to 09:00 hours on the next day.

Nap: a short sleep that was taken before, during, and after night shifts and ~2 h of napping was allowed once during the night shift at this facility.

Study design and participants

This study used a quantitative, descriptive, cross-sectional research design. Of the nurses who were invited to participate in the study, those who agreed to respond were recruited. The participants consisted of the nurses who engaged in the two-shift system, including 16 h night shifts in the general ward in Hospital A that had >200 beds in northern Japan. Only the nurses who were not on a vacation during the course of the study were included. The nurses were grouped into three categories of 25 each, based on their age as follows: 20–30 years, 30–40 years, and 40–50 years. Thus, a total of 75 nurses was included. The nurses who always took sleeping pills or were under treatment for any disease were excluded.

Measures

Sleep

Actigraph. The actigraph (Micro-mini RC; Ambulatory Monitoring, Inc., Ardsley, NY, USA) was used for the assessment of sleep. To analyze sleep, Cole's formulation with at least 90% of correlation in comparison with the polysomnogram was used.

To avoid artefacts, the participants were asked to wear the actigraph on the non-dominant wrist for a consecutive 9 days. After the data collection, the actigraph was connected to a personal computer via the interface for exclusive use of the actigraph. The data were downloaded via the exclusive software (ActMe; Ambulatory Monitoring, Inc.). Using software (AW2;

Ambulatory Monitoring, Inc.), the nurses' sleep was analyzed. The data that were recorded when the participants did not wear the actigraph were excluded from the analysis.

The sleep parameters that were used for the analysis were the following items: total sleep time (TST), sleep efficiency (SE), sleep-onset latency (SOL), wake min after sleep onset (WASO), start time of the main sleep, end time of the main sleep, the number of long (lasting ≥5 min) sleep episodes (LSEP), and the duration of the longest sleep episode (LGSEP). To explain further:

1 TST (min): sleep duration, the time when the first sleep block for ≥20 min was initiated in bed for the first time was defined as the sleep-onset time.
2 Sleep efficiency (%): the percentage of all sleep time accounts for the time from initiation of sleep to getting up.
3 SOL: the time from the onset of the resting stage to the initiation of sleep (the time when the first sleep episode for ≥20 min was initiated).
4 WASO: the wake min during sleep onset to sleep-offset interval.
5 LSEP: the total number of sleeping blocks for at least 5 min during sleep.
6 LGSEP: the duration of the longest sleep episode (min).

Sleep diary. The participants were asked to record their activities, sleep time, daytime sleepiness, number of occasions of alcohol intake, and any medication that was taken over the period during which they wore the actigraph.

Morningness–Eveningness Questionnaire

The Morningness–Eveningness Questionnaire (MEQ), which was developed by Horne and Östberg (1976), was used in translation to Japanese. Based on each participant's MEQ score, their circadian typology was classified as falling into one of five categories: definite morning type, moderate morning type, intermediate type, moderate evening type, or definite evening type. The participants were asked to complete the questionnaire at the beginning of the study.

Fatigue

Cumulative Fatigue Symptoms Index

The Cumulative Fatigue Symptoms Index (CFSI) that was developed by Kosugo (1991) and Fujii, Kosugo, and Hirata (1993) was used. The CFSI evaluates the signs of the workers' cumulative fatigue and comprises 81 questions. The participants answer each question by choosing between two options. The CFSI is composed of eight characteristic groups of items: for physical aspects, "general fatigue," "chronic fatigue sign," and "physical disorders"; for mental aspects, "depressive feelings," "anxiety," and "decreased vitality"; for social aspects, "irritability" and "unwillingness to work." The rate of positive items is shown as the complaint rate. According to Kosugo's criteria, the complaint rate is calculated as follows (Fujii *et al.*, 1993): Complaint rate (%) = (number of positive items/[number of each category items × number of participants]) × 100. The participants were asked to complete the CFSI initially and at 1 week and 1 month after the initiation.

Subjective feelings of fatigue. The subjective fatigue symptoms were assessed with a questionnaire on work-related fatigue called the "Jikaku-sho shirabe" (Kubo *et al.*, 2008), which was proposed by the Industrial Fatigue Research Committee of Japanese Occupational Health in 2002. This questionnaire comprises 25 items of subjective fatigue that are categorized into five factors: Group I, sleepiness; Group II, unstable feeling; Group III, unpleasantness; Group IV, tiredness; Group V, blurriness. In each question item, the participants chose one from the following options: "strongly disagree" (1 point); "disagree" (2 points); "slightly agree" (3 points); "agree" (4 points); "strongly agree" (5 points). A higher score indicates more fatigue. The participants were asked to complete the questionnaire twice per day; that is, before and after work on duty days and at the wake-up time and bed time on days off. The total score was used: before work and the wake time as a total score of "before" and after work and bedtime as a total score of "after" to compare their subjective feeling of fatigue as a function of nap and sleep.

Demographics

The participants were asked to provide personal details of their age, sex, Body Mass Index, years of experience as a nurse, years of nursing experience in their current ward, number of dependents at home requiring nursing or care, any disease under treatment, and any medication that they were taking.

Statistical analysis

Descriptive statistics were computed for each dependent variable. The Kruskal–Wallis test and Tukey's Honestly Significant Difference test were used to identify a variation in sleep patterns that was associated with age. The

Jikaku-sho shirabe questionnaire's subjective fatigue scores were collated for each participant and categorized as "before" scores (collected before starting work and at wake-up on days off) or "after" scores (collected at the end of work and at bedtime on days off). The "before" and "after" scores were highly correlated ($r = 0.7$, $P < 0.01$); therefore, the participants were divided into two groups, with a high and low degree of subjective fatigue based on the median "after" score. The student's *t*-test was used to compare the sleep parameters between the two groups.

The groups were divided by sleep as follows: napping before night shifts, napping during night shifts, and napping after night shifts. Also, the groups were divided by their sleep start time at a median value (00:25 hours) as follows: at night after night shifts and at night before day shifts. After evaluating the relationship between these groups and fatigue, two variables, the start time of the night-time sleep after a night shift and the timing of the nap following a night shift, were combined to examine the relationship of the overall sleeping pattern after a night shift with fatigue.

The Chi-squared test and Fisher's exact test were used to compare the duration and timing of naps taken before, during, and after a night shift between the two groups.

Radar charts that represented the mean complaint rate in each category of the CFSI are presented to compare the following groups: the nurses who napped for >2 h during their night shift, compared to those who did not; the nurses who napped in the morning after their night shift, compared to those who did not; and those following a generally early sleeping pattern, compared to those following a generally late sleeping pattern. The actigraphy data were analyzed for 49 participants; the others were excluded as a result of missing data. There were three participants for whom only the first day of their night shift was included in the data collection period and two for whom only the second day was included; these participants were excluded from the analyses comparing a variation in fatigue by sleep start time and napping pattern.

IBM SPSS Statistics for Windows v. 24 (IBM Corporation, Armonk, NY, USA) was used to carry out all the statistical analyses and the significance threshold was set at 5%.

Ethical considerations

This study was approved by the ethical review board of the authors' affiliated university and of the participating facility. The participants were informed of the purpose, procedures, and potential publication of this study, as well as their rights of refusal and confidentiality. Written informed consent was obtained from the participants.

RESULTS

Participants' characteristics

In total, 61 participants were recruited to take part in this study. After the exclusion of two who withdrew and four who did not work a night shift during the data collection period, the remaining participants were 27 (44.3%) nurses in their 20s, 25 (40.9%) in their 30s, and nine (14.7%) in their 40s. In terms of their chronotype, the intermediate type accounted for 73.8% of the participants and there was no participant with the definitely morning type or definitely evening type of circadian typology. The nurses who lived with family members and who needed child rearing and care were only six persons in their 30s (Table 1).

Data on the participants' sleeping and napping patterns

Sleep

The average total sleep time across all the participants was 8.3 ± 1.4 h daily; the subgroup average was 8.6 ± 1.3 h among the participants in their 20s and 8.7 ± 2.0 h among those in their 40s. The average main sleep start time across all participants was 00:30 ± 1:03 hours, with half of the participants beginning their night-time sleep after 00:00 hours. The participants in their 20s recorded a significantly later average sleep onset (01:00 ± 0:49 hours) and offset (08:48 ± 1:11 hours) time than those in their 40s (23:58 ± 0:54 hours and 07:25 ± 0:39 hours, respectively); in general, the sleep phases tended to be delayed as the participants aged (Table 2). There were no significant differences in sleep duration or timing based on the basic attributes, such as years of experience in the department or number of overtime hours.

Napping

Compared to the napping recommendation given in the guidelines, the overall proportion of participants who napped before a night shift was low, at 39.0%. The rates of napping during and after a night shift were high, at 91.5% and 89.7%, respectively. However, the proportions of participants who napped for ≥2 h or

Table 1 Participants' characteristics

Characteristic	Total (n = 61)	Age (years)			P-value
		20s (n = 27)	30s (n = 25)	40s (n = 9)	
Sex					–
Male: N (%)	2 (3.3)	0 (0.0)	1 (1.6)	1 (1.6)	
Female: N (%)	59 (96.7)	27 (44.3)	24 (39.3)	8 (13.1)	
Body Mass Index: kg/m^2	21.5 ± 3.5 (20.7)	20.9 ± 3.4 (20.6)	22.1 ± 3.7 (21.3)	21.5 ± 2.7 (20.6)	0.265
Years of nursing experience	8.7 ± 5.5 (7.5)	4.5 ± 1.6 (4.6)	11.0 ± 3.6 (10.6)	14.6 ± 8.3 (15.4)	<0.001
Years of nursing experience at the affiliated department	2.4 ± 2.0 (1.7)	1.6 ± 1.6 (1.2)	3.2 ± 2.1 (2.5)	2.8 ± 1.9 (2.4)	0.001
Child rearing or care: N (%)	8 (12.3)	0 (0.0)	6 (9.8)	0 (0.0)	–
Night shifts during the study period: times	1.6 ± 0.6 (2.0)	1.6 ± 0.6 (2.0)	1.6 ± 0.6 (2.0)	1.7 ± 0.7 (2.0)	0.886
Commuting time: min	31.9 ± 16.3 (30.0)	31.5 ± 15.8 (30.0)	32.9 ± 19.2 (30.0)	30.0 ± 8.3 (30.0)	0.997
Overtime h/month: N (%)					0.704
<10 h	40 (65.6)	17 (27.9)	16 (26.2)	7 (11.5)	
10 h ≤	21 (34.4)	10 (16.4)	9 (14.8)	2 (3.3)	
Medications: N (%)					–
Yes	6 (9.8)	2 (3.3)	2 (3.3)	2 (3.3)	
No	55 (90.2)	25 (41.0)	23 (37.7)	7 (11.5)	
Alcohol consumption: times during study	1.2 ± 1.9 (0.0)	1.0 ± 1.8 (0.0)	1.3 ± 2.0 (0.0)	1.4 ± 2.3 (0.0)	0.288
Chronotype: N (%)					–
Moderately morning type	4 (6.5)	0 (0.0)	4 (6.6)	0 (0.0)	
Moderately evening type	12 (19.7)	8 (13.1)	3 (4.9)	1 (1.6)	
Intermediate type or neither type	45 (73.8)	19 (31.1)	18 (29.5)	8 (13.1)	

Data are presented as N (%) or the mean ± standard deviation (median). The chronotype preference was verified by using the Morningness–Eveningness Questionnaire.

more during their night shift and in the morning after their night shift were low, at 50.8% and 32.8%, respectively. The proportion of participants who napped before their night shift was lower in every age group, but especially among the participants in their 20s, of whom 73.1% did not take such a nap. Among the participants in their 20s, 20.0% did not take a nap after a night shift (Table 3).

Relationship between sleeping and napping patterns and subjective fatigue in each group

There was no major difference in age between the high and low subjective fatigue groups.

Relationship between the main sleep pattern and fatigue

There were no significant differences between the two groups in terms of the sleep variables (Table 4). However, in a comparison of the sleep start time for the night-time sleep following a night shift, there were significantly more participants with a sleep onset time after 00:25 hours than with a sleep onset time before 00:26 hours in the high fatigue group (Table 4). There were no significant differences between the two groups in terms of the basic attributes, such as age, years of nursing experience, number of night shifts, overtime hours, chronotype, and child rearing or care.

Relationship between napping and fatigue

The timing of the naps that were taken before and after the night shift and the duration of the naps taken during the night shift were compared between the high- and low-fatigue groups. There was no significant difference between the groups on these items (Table 4).

Relationship between naps and sleep timing and fatigue

Two variables, the start time of the night-time sleep after a night shift and the timing of the nap following a night shift, were combined to examine the relationship

Table 2 Comparison of sleep, subjective feelings of fatigue, and cumulative fatigue by age

Variable	Total (n = 49)	Age (years)			P-value
		20s (n = 21)	30s (n = 19)	40s (n = 9)	
Sleep					
TST (h)	8.3 ± 1.4 (8.1)	8.6 ± 1.3 (8.5)	7.8 ± 0.9 (7.8)	8.7 ± 2.0 (8.2)	0.053
SE (%)	96.1 ± 2.3 (96.2)	96.5 ± 1.8 (96.2)	95.5 ± 2.7 (95.9)	96.4 ± 2.5 (96.6)	0.659
SOL (min)	16.1 ± 10.3 (14.6)	17.3 ± 13.3 (14.6)	15.2 ± 6.4 (14.6)	14.9 ± 10.0 (10.5)	0.870
WASO (min)	14.0 ± 8.7 (12.1)	13.2 ± 7.9 (10.1)	15.0 ± 9.8 (12.4)	13.6 ± 9.0 (14.8)	0.919
Stime of the main sleep	00:30 ± 1:03 (00:29)	01:00 ± 0:49 (01:08)*	00:12 ± 1:08 (00:10)*	23:58 ± 0:54 (00:09)*	0.015
Etime of the main sleep	08:14 ± 1:16 (8:17)	08:48 ± 1:11 (8:50)**	08:01 ± 1:20 (8:25)**	07:25 ± 0:39 (7:34)**	0.009
LSEP (times)	2.5 ± 1.4 (2.2)	2.4 ± 1.3 (2.2)	2.1 ± 1.4 (1.9)	3.3 ± 1.5 (3.6)	0.076
LGSEP (h)	3.4 ± 1.2 (3.3)	3.7 ± 1.1 (3.3)	3.1 ± 1.4 (3.1)	3.4 ± 1.0 (3.7)	0.243
Subjective feelings of fatigue					
Before	41.8 ± 14.2 (39.0)***	41.7 ± 12.5 (39.8)***	42.3 ± 17.5 (36.4)**	42.6 ± 11.7 (39.0)	0.856
After	48.0 ± 15.2 (45.7)***	48.2 ± 14.9 (45.7)***	48.2 ± 17. 7 (43.0)***	48.3 ± 9.9 (48.0)	0.828
Cumulative fatigue					
Depressive feelings	29.7 ± 23.5 (22.2)	30.7 ± 25.6 (18.5)	29.2 ± 21.2 (22.2)	28.4 ± 25.5 (22.2)	0.926
Anxiety	26.1 ± 23.4 (18.2)	29.7 ± 27.7 (18.2)	20.9 ± 16.6 (18.2)	28.6 ± 25.4 (27.3)	0.748
Decreased vitality	34.7 ± 30.2 (29.6)	34.9 ± 34.4 (25.9)	32.4 ± 24.1 (29.6)	39.1 ± 34.4 (33.3)	0.918
Irritability	20.8 ± 22.5 (14.3)	19.5 ± 24.1 (4.8)	20.8 ± 22.5 (14.3)	23.8 ± 20.5 (23.8)	0.698
Unwillingness to work	26.5 ± 25.2 (20.5)	24.7 ± 26.3 (12.8)	27.3 ± 25.7 (28.2)	29.1 ± 24.0 (30.8)	0.883
General fatigue	40.0 ± 21.7 (36.7)	41.7 ± 23.5 (40.0)	37.0 ± 19.1 (36.7)	42.2 ± 24.4 (46.7)	0.862
Chronic fatigue sign	50.8 ± 26.0 (45.8)	54.2 ± 29.0 (50.0)	47.4 ± 24.1 (41.7)	50.0 ± 24.7 (50.0)	0.647
Physical disorders	21.8 ± 17.1 (19.0)	22.0 ± 19.8 (14.3)	19.5 ± 14.3 (19.0)	25.9 ± 16.9 (23.8)	0.620

*P < 0.05, **P < 0.01, and ***P < 0.001. Kruskal–Wallis test, post-hoc test, Wilcoxon signed-rank test. The data are presented as the mean ± standard deviation (median). Etime, the average of the ending time of the main sleep in the study period; LGSEP, the duration of the longest sleep episode; LSEP, a long sleep episode (≤5 min) in an activity time interval; SE, sleep efficiency (100 × Sleep min/[sleep onset–sleep offset duration]); SOL, sleep onset latency; Stime, the average of the starting time of the main sleep in the study period; subjective feelings of fatigue "before," the beginning of work and the waking time on days off; subjective feelings of fatigue "after," the end of working and bedtime; TST, total sleep time; WASO, wake min during the sleep onset–sleep offset interval.

of the overall sleeping pattern after a night shift with fatigue.

An early group was defined as consisting of those participants who would take a nap in the morning after a night shift and start their night-time sleep that night before 00:26, while the late group consisted of the participants who would take a nap in the afternoon after a night shift and start their night-time sleep after 00:25 that night. There was no significant difference between the high and low subjective fatigue groups in terms of membership in the early group, compared to the late group (Table 4).

Relationship between sleep and cumulative fatigue

In a comparison of the CFSI scores, the average complaint rates for a decrease in vitality, unwillingness to work, general fatigue, and signs of chronic fatigue were significantly lower, by 12–19%, among those participants who napped for ≥2 h during their night shift than among the other participants (Fig. 1). There were no significant differences between the two groups in terms of their basic attributes, such as age, years of nursing experience, number of night shifts, overtime hours, chronotype, and child rearing or care.

There was no significant difference between the participants who took a nap in the morning following a night shift and the other participants (Fig. 2). However, in a comparison between the early and late groups, as defined above, the average complaint rate was 10–25% lower among the early group than among the late group; specifically, the complaint rates were significantly lower among the early group for anxiety, decrease in vitality, unwillingness to work, and signs of chronic fatigue (Fig. 3). There were no significant differences between the two groups in terms of their basic attributes, such as age, years of nursing experience, number of night shifts, overtime hours, chronotype, and child rearing or care.

Table 3 Ratio of napping before, during, and after night shifts

Before night shift			During night shift			After night shift		
Age (years)	Total nap a.m. nap/p.m. nap	No nap	Age (years)	Nap 2h ≤ / <2 h	No nap	Age (years)	Total nap a.m. nap/p.m. nap	No nap
Total (*n* = 59)	23 (39.0)	36 (61.0)	Total	54 (91.5)	5 (8.5)	Total (*n* = 58)	52 (89.7)	6 (10.3)
	16 (27.1)/7(11.9)	–	(*n* = 59)	30 (50.8)/24 (40.7)	–		19 (32.8)/33 (56.9)	–
20s (*n* = 26)	7 (26.9)	19 (73.1)	20s (*n* = 26)	24 (92.3)	2 (7.7)	20s (*n* = 25)	20 (80.0)	5 (20.0)
	2 (7.7)/5(19.2)	–		13 (50.0)/11 (42.3)	–		7 (28.0)/13 (52.0)	–
30s (*n* = 24)	13 (54.2)	11 (45.8)	30s (*n* = 24)	22 (91.7)	2 (8.3)	30s (*n* = 25)	24 (96.0)	1 (4.0)
	11 (45.8)/2 (8.3)			12 (50.0)/10 (41.7)			9 (36.0)/15 (60.0)	
40s (*n* = 9)	3 (33.3)	6 (66.7)	40s (*n* = 9)	8 (88.9)	1 (11.1)	40s (*n* = 8)	8 (100.0)	0 (0.0)
	3 (33.3)/0 (0.0)			5 (55.6)/3 (33.3)			3 (37.5)/5 (62.5)	

Data are presented as N (%).

Table 4 Comparison of sleep and nap by the subjective fatigue degree

		Subjective feelings of fatigue[†]		
Variable		High Group (*n* = 25)	Low Group (*n* = 24)	*P*-value
Age: N (%)		20s = 11 (44.0)	20s = 10 (41.7)	–
		30s = 9 (36.0)	30s = 10 (41.7)	–
		40s = 5 (20.0)	40s = 4 (16.7)	–
TST (h)		8.6 ± 1.6	8.0 ± 1.0	0.082
SE (%)		96.4 ± 2.5	95.8 ± 2.2	0.387
SOL (min)		14.6 ± 8.7	17.6 ± 11.8	0.326
WASO (min)		12.5 ± 8.9	15.5 ± 8.4	0.235
Stime of the main sleep		0:37 ± 1:06	0:22 ± 0:59	0.412
Etime of the main sleep		8:16 ± 1:03	8:13 ± 1:30	0.885
LSEP (times)		2.7 ± 1.5	2.2 ± 1.3	0.198
LGSEP (h)		3.6 ± 1.5	3.2 ± 1.0	0.267
Starting time of sleep				
Night after a night shift (*n* = 56)	≤00:25	8 (27.6)	16 (59.3)	0.017
	00:25 <	21 (72.4)	11 (40.7)	
Night before a day shift (*n* = 61)	≤00:25	19 (61.3)	20 (66.7)	0.662
	00:25 <	12 (38.7)	10 (33.3)	
Nap				
Before a night shift (*n* = 59)	Nap	13 (43.3)	10 (34.5)	0.486
	No nap	17 (56.7)	19 (65.5)	–
During a night shift (*n* = 59)	Nap time 2 h ≤	13 (43.3)	17 (58.6)	0.240
	Others	17 (56.7)	12 (41.4)	–
After a night shift (*n* = 58)	Nap in a.m.	8 (27.6)	11 (37.9)	0.401
	Others	21 (72.4)	18 (62.1)	–
Starting time of night sleep after night shifts and the nap time after night shifts (*n* = 29)	Early Group	3 (17.6)	5 (41.7)	0.158
	Late Group	14 (82.4)	7 (58.3)	–

[†]High Group and the Low Group were classified based on the median value. Sleep was analyzed by using the Student's *t*-test. The start times of the nap and sleep were analyzed by using a Chi-squared test and Fisher's exact test. The data are presented as the mean ± standard deviation or N (%). Etime, the average ending time of the main sleep in the study period; LGSEP, duration of the longest sleep episodes; LSEP, long sleep episode (≤5 min) in the activity time interval; night before the day shift and night on holiday before the day shift: Early Group, the participants who would take a nap in the morning after a night shift and start their night-time sleep that night before 00:26 hours and Late Group, the participants who would take a nap in the afternoon after a night shift and start their night-time sleep that night after 00:25 hours; SE, sleep efficiency; SOL, sleep onset latency; Stime, the average starting time of the main sleep in the study period; TST, total sleep time; WASO, wake after sleep onset.

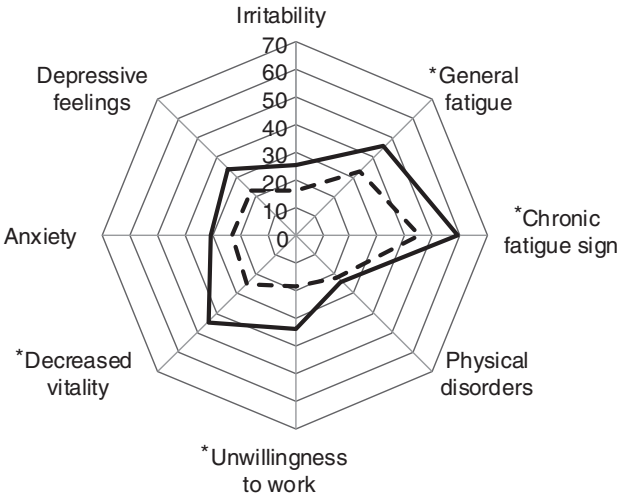

Figure 1 Comparison of the mean complaint rate (%) of the Cumulative Fatigue Symptoms Index by nap time during night shifts (n = 59). Each item was compared by using the Student's t-test. *P < 0.05. (- - - -) Nap time ≤2 h (n = 30); (——) others (n = 29).

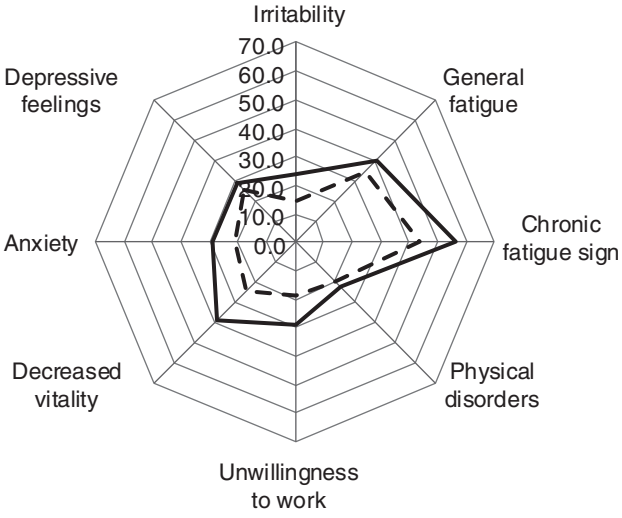

Figure 2 Comparison of the mean complaint rate (%) of the Cumulative Fatigue Symptoms Index by nap time after night shifts (n = 58). Each item was compared by using the Student's t-test. (- - - -) a.m. Nap (n = 19); (——) others (n = 39).

DISCUSSION

Sleeping and napping patterns of the nurses who were working 16 h night shifts

Generally, in shift work, sleep is disturbed by circadian rhythm modulation and the loss of sleep time is reported (Colten & Altevogt, 2006; Flynn-Evans *et al.*, 2018; Geiger-Brown *et al.*, 2012). However, the average sleeping time of the participants in this study period was 8.3 ± 1.4 h and they did get sufficient sleep, unlike the 12 h shift work nurses (Geiger-Brown *et al.*, 2012; Wilson *et al.*, 2017). The participants in this study showed a high level of cumulative fatigue. Therefore, it is considered that the participants should eliminate high cumulative fatigue by adopting a long sleeping time. As mentioned previously, the guidelines by the Japanese Nursing Association recommended nurses' appropriate way of napping.

In the present study, the proportion of participants who napped during their night shift was as high as ~90%, but the duration of this nap was <2 h in ~50% of cases. In addition, the rate of napping before a night shift was 39% and the rate of napping in the morning after a night shift was as low as ~33%. In other words, although the nurses generally did nap, it is clear that the proportion of nurses who were following a napping pattern in accordance with the guidelines was very low.

Among the participants in their 20s, the rate of napping was low: 73% of the participants did not take a nap before their night shift, 20% did not take a nap after their night shift, and 42% took a nap lasting <2 h during their night shift. Only 28% of the participants in this group took a nap in the morning after their night shift. In other words, the rate of napping was lower among the participants in their 20s than among those in the other age groups. Furthermore, in all age groups, the proportion of participants taking a nap of ≥2 h during their night shift and a nap in the morning following a night shift was low.

These findings are in accordance with those of Asaoka *et al.* (2013) that 92% of two-shift workers reported that they were given the opportunity to nap during their night shift, but that 43% reported that they always or often missed this opportunity as a result of their workload. The low rate of nap-taking described above could be attributed to the fact that it is difficult for nurses to find the time to nap as a result of the highly stressful, demanding, and time-pressured environment (Ruggiero & Redeker, 2014); avoiding a nap because of sleep inertia (Fallis, McMillan, & Edwards, 2011; Kubo *et al.*, 2010); and a quiet space that is appropriate for napping might be unavailable (Purnell, Feyer, & Herbison, 2002).

Relationship between napping and cumulative fatigue during a night shift

Naps are recommended to prevent performance deterioration and to reduce sleepiness in healthcare workers

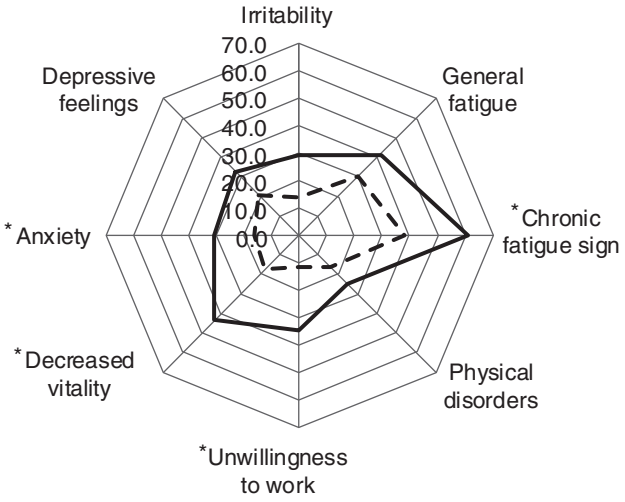

Figure 3 Comparison of the mean complaint rate (%) of the Cumulative Fatigue Symptoms Index of the Early Group and the Late Group (n = 29). Each item was compared by using the Student's t-test. *P < 0.05. (- - - -) Early Group (n = 8): the participants who would take a nap in the morning after a night shift and start their night-time sleep that night before 00:26 hours; (——) Late Group (n = 21): the participants who would take a nap in the afternoon after a night shift and start their night-time sleep that night after 00:25 hours.

(Barthe, Tirilly, Gentil, & Toupin, 2016; Dinges, Orne, Whitehouse, & Orne, 1987; Geiger-Brown *et al.*, 2016; Japanese Nursing Association, 2013; Lovato *et al.*, 2009; Smith-Coggins *et al.*, 2006). Taking a 120 min nap at 02:00–04:00 decreased the fatigue of nurses who were working a 16 h night shift (Oriyama & Miyakoshi, 2017). Kikuchi and Ishii (2015) reported that fatigue is high if nurses cannot take a nap during a night shift.

In contrast, it has been reported that sleepiness is strong and fatigue is not alleviated even if the nap time can be taken for 2 h because a 16 h night shift is maintained for the day-shift-oriented biological rhythm (Matsumoto *et al.*, 2008; Sasaki & Matsumoto, 2013).

However, as a result of the present study, it is now clear that a nap of >2 h during a night shift significantly reduces aspects of cumulative fatigue, such as a decrease in vitality, unwillingness to work, general fatigue, and signs of chronic fatigue.

These results suggest that shift workers who are exposed to stressors at night might experience difficulty in managing their physiological and mental responses to these stressors (James, Honn, Gaddameedhi, & Van Dongen, 2017).

Inappropriate nap-taking is known to be a factor in causing medical accidents, but this study further revealed that appropriate nap-taking also is associated with a decrease in demotivation and chronic fatigue, which in turn could reduce the turnover of nurses.

In addition, although there was no significant difference between the subjective feelings of fatigue and napping, a significant difference was recognized in the CFSI, which means that to evaluate the effect of a nap on fatigue, it might be necessary to focus on chronic fatigue, rather than acute fatigue.

Relationship between a nap and the main sleep start time and fatigue

Taking a nap in the morning following a night shift was not by itself effective in reducing cumulative fatigue. However, the results make it clear that cumulative fatigue was greatly alleviated by combining a morning nap with going to bed early the night after a night shift. This seems to be because there is a possibility that this sleeping pattern might avoid the tendency for sleep phases to shift gradually later.

A misalignment between the circadian pacemaker and the sleep–wake cycle can result in a shift work disorder (Barger *et al.*, 2012; Wright, Bogan, & Wyatt, 2013). Hospitalists can help to limit fatigue and improve performance and safety through circadian adaptation (Schaefer, Williams, & Zee, 2012). In other words, optimal timing of the nap that is taken after a night shift and the worker's bedtime that night not only prevents cumulative fatigue, but also could prevent disruption of the circadian rhythm and lower the risk of a shift work disorder.

Regarding the relationship between sleeping patterns and fatigue, Miyazaki and Hosona (2013) reported that the wake-up time in the morning before a night shift and wake-up time on an ordinary day are associated with fatigue after a night shift. In addition, in the present study, the results showed that the sleep onset time and napping pattern were related to fatigue.

The guidelines suggest taking a nap, but do not mention the effects of not doing so on the nurse's level of tiredness. In the present study, it was observed that it is not sufficient to merely take a nap at some point; napping at an appropriate time and for an appropriate duration is essential for nurses to avoid the symptoms of fatigue. In addition, it was clarified that the combination of the timing of the nurse's nap following a night shift and their bedtime that night is a significant factor in decreasing their levels of mental and social fatigue, including anxiety, a decrease in vitality, and unwillingness to work. The avoidance of these aspects of fatigue is essential for nurses to keep their motivation to work.

Based on the above findings, this study suggests that cumulative fatigue can be mitigated by nap-taking and timing the start of the night-time sleep appropriately. In future research, it will be necessary to carry out similar investigations with a larger number of participants and to replicate the findings.

Limitations of the study

The participants in this study were recruited from a single institution (a general hospital) in a single region. Therefore, there might be a bias (e.g. in the characteristics of the region or the institution) that means that it is difficult to generalize the results to all nurses in Japan who work in a two-shift system, including a 16 h night shift. The nap environment (i.e. the availability of a room and a bed for naps, napping position, darkness, and noise in the room during naps), lifestyle factors (i.e. coffee consumption, smoking), and nocturnal sleep conditions (i.e. the study participant is sleeping in a bed with a partner or alone during nocturnal sleep) influence the effects of a nap; however, this study did not investigate these factors.

In addition, the quality of sleep should be assessed by combining the participants' subjective feelings about their sleep with objective measures, while the present study measured only the latter. Furthermore, considering nurses' shift patterns and the need to allow for the loss of some data, it would be better to extend the actigraphy data collection period to 2 weeks.

CONCLUSION

The proportion of nurses who take naps before, during, and after their night shifts, in accordance with the published guidelines, was revealed to be low, at 27%–50%. It was found that taking a nap and timing bedtime appropriately after a night shift decreases cumulative fatigue and that this effect relates not only to physical fatigue but also to mental fatigue, the avoidance of which is related to factors that are important in the continuation of employment, such as keeping workers motivated. In addition, these results suggested speculation that an appropriate pattern of napping and night-time sleeping could help to avoid the collapse of the circadian rhythm, with sleep phases tending to shift gradually later. Therefore, it is suggested that nursing team leaders should ensure that a suitable environment for napping is available and that they should encourage a workplace culture that promotes taking a nap during night shifts and leaving promptly at the end of a shift.

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DISCLOSURE

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

H. K., N. S, Y. Y., N. S., F. N., and R. Y. contributed to the conception and design of this study; H. K., Y. Y., and N. S. contributed to the acquisition of the data; N. S. contributed to the analysis of the data; H. K. and R. Y. conducted the statistical analysis and drafted the manuscript; R. Y. critically reviewed the manuscript and supervised the whole study process. All the authors read and approved the final version of the manuscript.

REFERENCES

Asaoka, S., Aritake, S., Komada, Y., Ozaki, A., Odagiri, Y., Inoue, S. *et al.* (2013). Factors associated with shift work disorder in nurses working with rapid-rotation schedules in Japan: The nurses' sleep health project. *Chronobiology International*, *30*, 628–636.

Barger, L. K., Ogeil, R. P., Drake, C. L., O'Brien, C. S., Ng, K. T. & Rajaratnam, S. M. W. (2012). Validation of a questionnaire to screen for shift work disorder. *Sleep*, *35*, 1693–1703.

Barthe, B., Tirilly, G., Gentil, C. & Toupin, C. (2016). Job demands and resting and napping opportunities for nurses during night shifts: Impact on sleepiness and self-evaluated quality of healthcare. *Industrial Health*, *54*, 157–162.

Colten, H. R. & Altevogt, B. M. (2006). *Sleep disorders and sleep deprivation: An unmet public health problem*. Washington, DC: The National Academies Press.

Dall'Ora, C., Griffiths, P., Ball, J., Simon, M. & Aiken, L. H. (2015). Association of 12 h shifts and nurses' job satisfaction, burnout and intention to leave: Findings from a cross-sectional study of 12 European countries. *BMJ Open*, *5*, e008331. http://doi.org/10.1136/bmjopen-2015-008331.

Dinges, D. F., Orne, M. T., Whitehouse, W. G. & Orne, E. C. (1987). Temporal placement of a nap for alertness:

Contributions of circadian phase and prior wakefulness. *Sleep*, *10*, 313–329.

Fallis, W. M., McMillan, D. E. & Edwards, M. P. (2011). Napping during night shift: Practices, preferences, and perceptions of critical care and emergency department nurses. *Critical Care Nurse*, *31*, 1–12.

Flynn-Evans, E. E., Arsintescu, L., Gregory, K., Mulligan, J., Nowinski, J. & Feary, M. (2018). Sleep and neurobehavioral performance vary by work start time during non-traditional day shifts. *Sleep Health*, *4*, 476–484.

Fujii, H., Kosugo, R. & Hirata, A. (1993). Subjective assessment of workload (2) revision of the cummulative fatigue symptoms. *Science of Labour*, *69*, 1–9 (in Japanese).

Geiger-Brown, J., Rogers, V. E., Trinkoff, A. M., Kane, R. L., Bausell, R. B. & Scharf, S. M. (2012). Sleep, sleepiness, fatigue, and performance of 12-hour-shift nurses. *Chronobiology International*, *29*, 211–219.

Geiger-Brown, J., Sagherian, K., Zhu, S., Wieroniey, M. A., Blair, L., Warren, J. *et al.* (2016). CE: Original research: Napping on the night shift: A two-hospital implementation project. *American Journal of Nursing*, *116*, 26–33.

Griffiths, P., Dall'Ora, C., Simon, M., Ball, J., Lindqvist, R., Rafferty, A.-M. *et al.* (2014). Nurses' shift length and overtime working in 12 European countries. *Medical Care*, *52*, 975–981.

Hara, R. (2009). The workplace selection factor of the fourth-grade nursing college students who chose to get a job in a hospital as a nurse. *The Proceedings of the Japan Society of Nursing*, Nursing Administration, *2009*, 391–393 (in Japanese).

Horne, J. A. & Ostberg, O. (1976). A self-assessment questionnaire to determine morningness–eveningness in human circadian rhythms. *International Journal of Chronobiology*, *21*, 214–221.

Ichikawa, I. (1998). Does introducing a 2-shift system increase the fatigue of the nurse and lower the concentration ability? *Expert Nurse*, *14*, 126–132 (in Japanese).

James, S. M., Honn, K. A., Gaddameedhi, S. & Van Dongen, H. P. A. (2017). Shift work: Disrupted circadian rhythms and sleep – implications for health and well-being. *Current Sleep Medicine Reports*, *3*, 104–112.

Japan Federation of Medical Workers' Unions. (2016). *2016 Night shift survey report*. Japan Federation of Medical Workers' Unions, (No. 595), 9 (in Japanese).

Japanese Nursing Association. (2013). *Guidelines on night shift and shift work for nurses*. Tokyo: Japanese Nursing Association (in Japanese).

Kayahara, M. & Taniguchi, C. (2014). Actual state of nap time and subjective fatigue feeling in 2 h shift work of acute hospital nurse. The 44th Proceedings of The Japan Society of Nursing, Nursing Administration, 2014, 137–140 (in Japanese).

Kikuchi, Y. & Ishii, N. (2015). The relationship between self-awareness of fatigue symptoms and working conditions in female nurses. *Sangyo Eiseigaku Zasshi*, *57*, 230–240 (in Japanese).

Kosugo, R. (1991). Validity and reliability of Cumulative Fatigue Symptoms Index (CFSI). *The Journal of Science of Labour*, *67*, 145–157 (in Japanese).

Kubo, T., Tachi, N., Takeyama, H., Ebara, T., Inoue, T., Takanishi, T. *et al.* (2008). Characteristic patterns of fatigue feelings on four simulated consecutive night shifts by "Jikaku-sho shirabe". *Sangyo Eiseigaku Zasshi*, *50*, 133–144 (in Japanese).

Kubo, T., Takahashi, M., Takeyama, H., Matsumoto, S., Ebara, T., Murata, K. *et al.* (2010). How do the timing and length of a night-shift nap affect sleep inertia? *Chronobiology International*, *27*, 1031–1044.

Lee, M. L., Howard, M. E., Horrey, W. J., Liang, Y., Anderson, C., Shreeve, M. *et al.* (2016). High risk of near-crash driving events following night-shift work. *Proceedings of the National Academy of Sciences*, *113*, 176–181.

Lovato, N., Lack, L., Ferguson, S. & Tremaine, R. (2009). The effects of a 30-min nap during night shift following a prophylactic sleep in the afternoon. *Sleep and Biological Rhythms*, *7*, 34–42.

Matsumoto, S. (2015). Effects of changing the shift system of hospital nurses from 8-hour to 16-hour night shifts on their daily activities. *Journal of Science of Labour*, *91*, 39–44 (in Japanese).

Matsumoto, S., Sasaki, T., Sakita, M., Naito, K., Aoyagi, N., Takahashi, E. *et al.* (2008). The effects of naps taken by hospital nurses during 16-hour nightshifts on their subjective fatigue feelings and subsequent sleeps. *Journal of Science of Labour*, *84*, 25–29 (in Japanese).

Miyazaki, M. & Hosona, M. (2013). The relationship between sleeping patterns and fatigue among nurses on two-shift work schedules. *Kobe University Repository*, *29*, 1–15 (in Japanese).

Oriyama, S. & Miyakoshi, Y. (2017). The influence of a 120-minute nap on physical activity and subsequent sleep: Impact of nighttime napping during a simulated night shift. *Journal of Science of Labour*, *93*, 67–79 (in Japanese).

Purnell, M. T., Feyer, A. M. & Herbison, G. P. (2002). The impact of a nap opportunity during the night shift on the performance and alertness of 12-h shift workers. *Journal of Sleep Research*, *11*, 219–227.

Rhéaume, A. & Mullen, J. (2018). The impact of long work hours and shift work on cognitive errors in nurses. *Journal of Nursing Management*, *26*, 26–32.

Rogers, A. E., Hwang, W.-T., Scott, L. D., Aiken, L. H., Dinges, D. F. & Rogers, A. (2004). The working hours of hospital staff nurses and patient safety. *Health Affairs*, *23*, 202–212.

Ruggiero, J. S. & Redeker, N. S. (2014). Effects of napping on sleepiness and sleep-related performance deficits in night-shift workers: A systematic review. *Biological Research for Nursing*, *16*, 134–142.

Sasaki, T. & Matsumoto, S. (2013). Prevalence of the subjective sleepiness in nurses working 16-hour night shifts. *Journal of Science of Labour*, *89*, 218–224 (in Japanese).

Schaefer, E. W., Williams, M. V. & Zee, P. C. (2012). Sleep and circadian misalignment for the hospitalist: A review. *Journal of Hospital Medicine*, *7*, 489–496.

Scott, L. D., Hwang, W.-T., Rogers, A. E., Nysse, T., Dean, G. E. & Dinges, D. F. (2007). The relationship between nurse work schedules, sleep duration, and drowsy driving. *Sleep*, *30*, 1801–1807.

Scott, L. D., Rogers, A. E., Hwang, W.-T. & Zhang, Y. (2007). Effects of critical care nurses' work hours on vigilance and patients' safety. *American Journal of Critical Care*, *15*, 30–37.

Smith, S. S., Kilby, S., Jorgensen, G. & Douglas, J. A. (2007). Napping and nightshift work: Effects of a short nap on psychomotor vigilance and subjective sleepiness in health workers. *Sleep and Biological Rhythms*, *5*, 117–125.

Smith-Coggins, R., Howard, S. K., Mac, D. T., Wang, C., Kwan, S., Rosekind, M. R. *et al.* (2006). Improving alertness and performance in emergency department physicians and nurses: The use of planned naps. *Annals of Emergency Medicine*, *48*, 596–604.

Stimpfel, A. W., Sloane, D. M. & Aiken, L. H. (2012). The longer the shifts for hospital nurses, the higher the levels of burnout and patient dissatisfaction. *Health Affairs*, *31*, 2501–2509.

Takahashi, M., Fukuda, H., Miki, K., Haratani, T., Kurabayashi, L., Hisanaga, N. *et al.* (1999). Shift work-related problems in 16-h night shift nurses (2): Effects on subjective symptoms, physical activity, heart rate, and sleep. *Industrial Health*, *37*, 228–236.

Wilson, M., Permito, R., English, A., Albritton, S., Coogle, C. & Van Dongen, H. P. A. (2017). Performance and sleepiness in nurses working 12-h day shifts or night shifts in a community hospital. *Accident Analysis and Prevention*. http://doi.org/10.1016/j.aap.2017.09.023.

Wright, K. P., Bogan, R. K. & Wyatt, J. K. (2013). Shift work and the assessment and management of shift work disorder (SWD). *Sleep Medicine Reviews*, *17*, 41–54.

