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ORIGINAL ARTICLE

Association Between Sleep Quality and Subjective Fatigue in Night-Shift Nurses with Good and Poor Sleep

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Abstract

Purpose This study aimed to explore the association between sleep quality and subjective fatigue in nurses who performed rotational-shift work.

Methods A cross-sectional survey was conducted and included nurses working day and night shifts ($n = 35$) at Toyama University Hospital in Japan. To examine the influence of sleep quality on subjective fatigue, participants were categorized as poor ($n = 23$) or good ($n = 12$) sleepers. They assessed their own sleep status using the St Mary's Hospital Sleep Questionnaire and subjective fatigue following shift changes (holiday to day shift, day shift to day shift, before night shift, after night shift, and day shift to holiday).

Results Poor sleepers' State-Trait Anxiety Inventory scores were higher relative to those of good sleepers. Moreover, good sleepers recovered from subjective fatigue after sleep following all shift changes. Poor sleepers' subjective fatigue also reduced after sleep following 'before night shift', 'after night shift', and 'day shift to holiday' shift changes but not 'holiday to day shift' or 'day shift to day shift' shift changes. Sleep duration was stable across shift changes in good sleepers, and poor sleepers' sleep durations were significantly longer following 'before night shift', 'after night shift', and 'day shift to holiday' shift changes relative to those following 'holiday to day shift' and 'day shift to day shift' shift changes.

Conclusions The results suggested that poor sleepers' subjective fatigue following 'before night shift', 'after night shift', and 'day shift to holiday' could be reduced by increasing sleep duration, indicating that it is important to ensure sufficient sleep duration to improve all nurses' sleep quality and reduce poor sleepers' subjective fatigue. Furthermore, sufficient relaxation at bedtime and the reduction of anxiety are important in maintaining good sleep quality.

Keywords Nurse · Sleep quality · Sleep duration · Subjective fatigue · Rotational-shift work

1 Introduction

The association between shift work and fatigue in workers has been examined extensively [1–3]. In particular, rotational-shift workers, including those who work night shifts (e.g., nurses, police officers, airline pilots, and truck drivers), have been reported to experience greater life- or work-related problems relative to day-shift workers [4–6]. The problems related to rotational-shift work affect sleep [4–7] and work performance [4–6, 8]; furthermore, they lead to an increase in lifestyle-related health [9] risks such as obesity, diabetes [10], heart disease [11], depression, hypertension [12–14], and cancer [15]. Therefore, the improvement of rotational-shift workers' sleep quality and quality of life is important.

Individual differences in adaptation to rotational-shift work have been reported, and several studies have examined the effects of this adaptation on circadian phase, sleep quality, work performance, and the endocrine system in rotational-shift workers [16–21]. In addition, differences in adaptation and sleep status have been reported in nurses who work night shift [22, 23], and the severity of sleep problems during adaptation was attributed to accumulative subjective fatigue [22]. Adaptation to rotational-shift work has

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been shown to be influenced by individual personal factors such as age, chronotype of circadian rhythm, genotype, and light/darkness [19, 23, 24]. To maintain employees' health in rotational-shift work, it is important to assess individual shift workers' adaptation to work environments.

Shift work in nursing not only includes rotational-shift work, which disturbs circadian rhythm, but also leads to severe stress in the work environment. Nurses who work rotational shifts in Japan follow a two- or three-shift pattern. Previous studies have reported that the accumulation of subjective fatigue in those who followed a two-shift pattern was lower relative to that observed in those who followed a three-shift pattern [25]. Furthermore, job satisfaction in those who followed a two-shift pattern was higher relative to that observed in those who followed a three-shift pattern [25, 26]. Recently, use of the three-shift pattern has been reduced in Japan, and implementation of the two-shift pattern has increased. It is important to assess stress and fatigue in rotational-shift work including the two- and three-shift patterns.

In contrast, few studies have focused on the effects of shift changes (e.g., day-shift to day-shift or night-shift). Sleep status in nocturnal sleep before a night-shift has been reported to be worse relative to that observed after a night-shift [27]. However, to our knowledge, little is known about the effect of sleep on other shift changes. Examination of the relationship between sleep and fatigue following various shift changes is important, to improve the rotational-shift work system for nurses and improve their lifestyle-related health.

We hypothesized that there would be a difference in sleep and fatigue following shift changes in nurses who worked rotational shifts. Furthermore, we predicted that a difference in habitual sleep quality in nurses who worked rotational shifts would affect subjective fatigue following shift changes. To test these hypotheses, we examined whether sleep quality (good vs. poor) in nurses who worked rotational shifts affected sleep status and subjective fatigue when their shift patterns changed.

2 Methods

2.1 Participants

A cross-sectional study was conducted from November 1, 2014 to March 30, 2015 to examine sleep status and subjective fatigue in nurses who worked rotational shifts. Nurses who worked at Toyama University Hospital were recruited via a bulletin board advertisement, in which the study objective and procedure were described. In total, 35 nurses (31 women and 4 men; mean age ± standard deviation: 36.9 ± 10.0 years) were recruited as participants. All participants were treated in strict compliance with the Declaration of Helsinki and the US code of Federal Regulations for the Protection of Human Subjects. All participants understood the study and provided informed consent, and the study was approved by the Clinical Research and Ethics Committee at the University of Toyama.

2.2 Procedures

Participants completed a self-report questionnaire prior to this field session which was assessed their own subjective sleep and fatigue for a week. The questionnaire included items pertaining to sleep, psychological symptoms, and work and lifestyle habits. We used the Japanese version of the Pittsburgh Sleep Quality Index (PSQI) to assess subjective sleep quality over a 1-month period [28]; the scale consists of the following seven component scores (scores range from 0–3): sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleep medication, and daytime dysfunction. The Epworth Sleepiness Scale [29], which includes eight items pertaining to sleepiness, was used to measure sleepiness, with responses provided using a Likert scale ranging from 0 to 3. Psychological stress was measured using the State Trait Anxiety Inventory (STAI) [30], which has been used widely to assess state and acute anxiety. The participants were subdivided into two groups: those with PSQI scores of > 5 (n = 23; one man and 22 women) were assigned to the poor sleepers group, and those with PSQI scores of ≤ 5 (n = 12; three men and nine women) were assigned to the good sleeper group.

The participants assessed their own subjective sleep and fatigue according to the questionnaire over the course of a week, which began with a day off and included at least 1 day shift and one night shift. Shifts were categorized as follows: day shift (approximately 8:30–17:00); night-shift (approximately 15:30–9:00). Participants recorded their subjective sleep status in the morning and their subjective fatigue and sleepiness at bedtime and awakening time over the course of a week. Shift changes were categorized as follows: holiday to day shift (HDS), day shift to day shift (DDS), before night shift (BNS), sleep after night shift (ANS), and day shift to holiday (DSH).

2.3 Questionnaire

We assessed sleep status, subjective fatigue, and sleepiness at bedtime and awakening time for the five shift changes: sleep on the final day of a holiday period (for HDS), sleep on the final day of a day shift (for DDS), the final sleep before a night shift (for BNS), the first sleep following a night-shift (for ANS), and the final sleep on the day-shift preceding a holiday period (for DSH).

Subjective sleep status was evaluated using the St Mary's Hospital Sleep Questionnaire (SMHSQ) [31]. The

SMHSQ includes the following questions: "Was your Sleep (1) very light, (2) light, (3) fairly light, (4) light average, (5) deep average, (6) fairly deep, (7) deep, (8) very deep?" to assess sleep depth; "How well did you sleep last night? very badly (1), badly (2), fairly badly (3), fairly well (4), well (5), very well (6)" to assess sleep quality; "How clear-headed did you feel after getting up this morning? still very drowsy indeed (1), still moderately drowsy (2), still slightly drowsy (3), fairly clear-headed (4), alert (5), very alert (6)" to assess refreshment; "How satisfied were you with last night's sleep? very unsatisfied (1), moderately unsatisfied (2), slightly unsatisfied (3), fairly satisfied (4), completely satisfied (5)" to assess sleep satisfaction; and "How much difficulty did you have in getting off to sleep last night? none or very little (1), some (2), a lot (3), extreme difficulty (4)" to assess sleep difficulty. Sleepiness was assessed using the nine-item Karolinska Sleepiness Scale. Subjective fatigue was recorded on a visual analog scale value (VAS) ranged from 0 (not at all tired) to 10 (extremely tired). Subjective fatigue on VAS has been reported to linearly correlate with autonomic nervous activity [32, 33]. Participants rated their subjective fatigue and sleepiness at bedtime and awakening time at home. Sleep duration was measured using the SMHSQ.

2.4 Statistical Analysis

Values are expressed as means ± standard deviations. Comparisons between poor and good sleepers were performed using Mann–Whitney *U* tests. Changes in subjective fatigue and sleepiness were analyzed using a Wilcoxon signed-rank test. Bivariate correlations between PSQI and STAI were estimated Spearman's correlation coefficients. Sleeping duration was analyzed via a one-way analysis of variance. All statistical analyses were performed using SPSS for windows (Ver. 20, IBM). All p values were two tailed, and the significance level was set at $p < 0.05$.

3 Results

3.1 Participants' Demographic Characteristics

The comparison of demographic characteristics between poor and good sleepers is summarized in Table 1. Participants' ages did not differ significantly between poor and good sleepers. Four components of the PSQI (sleep quality, sleep latency, use of sleep medication, and daytime dysfunction), differed significantly between poor and good sleepers ($p = 0.002$, $p = 0.016$, $p < 0.001$, and $p < 0.001$, respectively). STAI scores in poor sleepers were higher relative to those observed in good sleepers ($p = 0.044$). There was no significant difference in Epworth Sleepiness Scale scores between poor and good sleepers.

Table 1 Participants' demographic characteristics according to group

Variable[a]	Poor sleepers[b] ($n = 23$)	Good sleepers[b] ($n = 12$)	p
Age (years)	36.0 ± 8.4	38.5 ± 12.4	0.776
PSQI	8.1 ± 2.0	3.8 ± 1.2	0.001
Sleep quality	1.7 ± 0.6	1.0 ± 1.0	0.002
Sleep latency	1.6 ± 1.0	0.5 ± 0.5	0.016
Sleep duration	1.8 ± 0.6	1.1 ± 1.1	0.088
Sleep efficiency	0.5 ± 0.8	0.1 ± 0.1	0.380
Sleep disturbance	0.9 ± 0.3	0.8 ± 0.8	0.086
Sleep medication	0.5 ± 1.0	0.0 ± 0.0	< 0.001
Daytime dysfunction	1.3 ± 0.6	0.3 ± 0.3	< 0.001
ESS	10.0 ± 5.0	8.2 ± 4.0	0.272
STAI	52.6 ± 10.3	45.3 ± 8.0	0.044

ESS Epworth sleepiness scale, *PSQI* Pittsburgh sleep quality index, *STAI* State trait anxiety inventory

[a]Comparisons between poor and good sleepers were performed using Mann–Whitney *U* tests

[b]All values are represented by means ± standard deviations

Table 2 shows the correlation between STAI and overall PSQI and PSQI component scores. STAI scores were significantly correlated with the overall PSQI score and the following three component scores: sleep quality, sleep latency, and sleep efficiency.

3.2 Subjective Fatigue and Sleepiness

Figure 1 shows subjective fatigue and sleepiness in poor and good sleepers for the HDS, DDS, BNS, ANS, and DSH shift changes. In good sleepers, subjective fatigue decreased significantly from bedtime to awakening time for all shift changes (Wilcoxon signed-rank test). However, in poor sleepers, a significant decrease in subjective fatigue was observed only in the BNS, ANS, and DSH shift changes. Relative to that observed in good sleepers, subjective fatigue at awakening time for the HDS and DDS shift changes was significantly higher in poor sleepers (Mann–Whitney *U* test). Subjective sleepiness also decreased significantly in good sleepers for all shift changes. No significant changes in sleepiness were observed at awakening time in poor sleepers for day-shift patterns (i.e., HDS and CDS shift changes).

3.3 Subjective Sleep Status

Table 3 summarizes subjective sleep status at awakening time, represented by SMHSQ scores, in poor and good sleepers. For the HDS shift change, levels of sleep quality

Table 2 Correlations between STAI and PSQI scores

	PSQI scores							
	Total	C1[a]	C2[b]	C3[c]	C4[d]	C5[e]	C6[f]	C7[g]
STAI scores								
Rho	0.36	0.35	0.48	0.01	0.36	0.15	– 0.27	0.28
p value	0.036	0.041	0.003	0.952	0.034	0.401	0.118	0.099

PSQI Pittsburgh sleep quality index, *STAI* state trait anxiety inventory

[a]C1: Sleep quality

[b]C2: Sleep latency

[c]C3: Sleep duration

[d]C4: Sleep efficiency

[e]C5: Sleep disturbance

[f]C6: Sleep medication

[g]C7: Daytime dysfunction

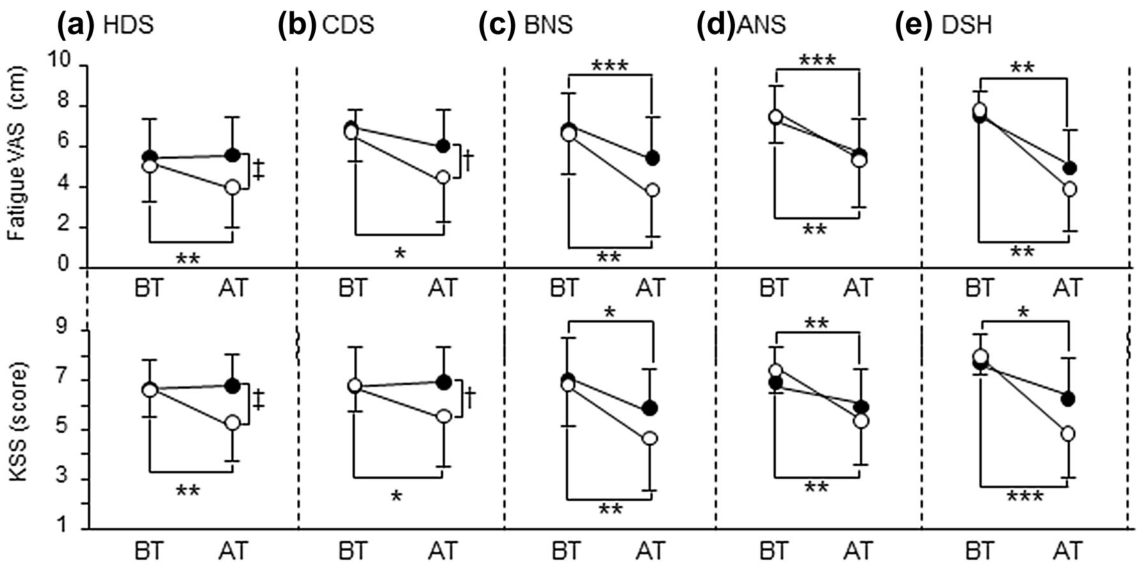

Fig. 1 Subjective fatigue and sleepiness in nurses. Subjective fatigue (upper panel) and sleepiness (lower panel) in good sleepers (represented by open circles) and poor sleepers (represented by filled circles) at bedtime and awakening time. The five changes in these factors were as follows: **a** from holiday to day-shift, **b** day-shift to day-shift, **c** before night-shift, **d** after night-shift, and **e** day-shift to holiday. All values represent means ± standard deviations. Comparisons between poor and good sleepers performed using Mann–Whitney *U* tests: $^{\dagger}p < 0.05$, $^{\ddagger}p < 0.01$. Comparisons between bedtime and awakening time performed using Wilcoxon signed-rank tests; $^{*}p < 0.05$, $^{**}p < 0.01$. *ANS* after night shift, *AT* awakening time, *BT* bedtime, *DDS* day shift to day shift, *DSH* day shift to holiday, *HDS* holiday to day shift, *KSS* Karolinska Sleepiness Scale, *VAS* visual analog scale

and refreshment in poor sleepers were significantly lower relative to those observed in good sleepers ($p < 0.05$, Mann–Whitney *U* test). For the DDS shift change, levels of refreshment and sleep satisfaction were lower and levels of sleep difficulty were higher in poor sleepers, relative to those observed in good sleepers ($p < 0.10$, Mann–Whitney *U* test). Levels of sleep quality for the BNS shift change were significantly lower and levels of sleep difficulty for the BNS and DSH shift changes were significantly higher in poor sleepers, relative to those observed in good sleepers.

Sleep durations for the two groups are shown in Fig. 2. In good sleepers, sleep durations did not differ significantly between the HDS, DDS, BNS, ANS, and DSH shift changes, $F(4, 56) = 1.37$, $p > 0.05$. However, sleep durations differed significantly in poor sleepers, $F(4, 106) = 8.70$, $p < 0.001$. Post hoc tests indicated that sleep duration in the BNS, ANS, and DSH shift changes were significantly longer relative to those observed in the HDS and DDS shift changes (Tukey's test).

Table 3 St Mary's Hospital sleep questionnaire scores

Variable[a]		HDS[b]	DDS[b]	BNS[b]	ANS[b]	DHS[b]
Sleep depth	PSR	4.3 ± 1.6	5.1 ± 1.4	4.6 ± 1.5	5.2 ± 1.3	5.0 ± 1.2
Light < deep	GSR	4.8 ± 1.3	4.9 ± 1.2	5.2 ± 1.8	5.1 ± 1.9	5.1 ± 1.6
Sleep quality	PSR	3.5 ± 1.1*	3.7 ± 1.2	3.8 ± 1.0*	3.9 ± 0.9	3.8 ± 0.9
Badly < well	GSR	4.3 ± 1.0	4.1 ± 1.1	4.5 ± 1.2	4.6 ± 1.4	4.4 ± 1.1
Feeling refreshed	PSR	2.3 ± 1.0*	2.3 ± 1.1**	3.2 ± 1.1	2.7 ± 1.0	2.8 ± 1.1
Still very drowsy < alert	GSR	3.1 ± 1.2	3.1 ± 1.3	3.8 ± 1.3	3.3 ± 1.1	3.1 ± 1.4
Sleep satisfaction	PSR	2.9 ± 1.0	3.0 ± 0.8**	3.3 ± 0.9	3.4 ± 0.7	3.5 ± 0.8
Unsatisfied < satisfied	GSR	3.4 ± 0.8	3.5 ± 0.8	3.6 ± 0.9	3.4 ± 1.2	4.0 ± 1.1
Sleep difficulties	PSR	1.7 ± 0.7	1.5 ± 0.6**	1.7 ± 0.8*	1.4 ± 0.8	1.7 ± 0.6*
Very little < difficult	GSR	1.5 ± 0.6	1.3 ± 0.9	1.2 ± 0.6	1.2 ± 0.4	1.1 ± 0.3

Comparisons were performed between poor and good sleepers; all values are presented as means ± standard deviations

GSR good sleeper, *PSR* poor sleeper

*Significant difference from good sleepers ($p < 0.05$, Mann–Whitney *U* test); ** marginally significant difference from good sleepers ($p < 0.10$, Mann–Whitney *U* test)

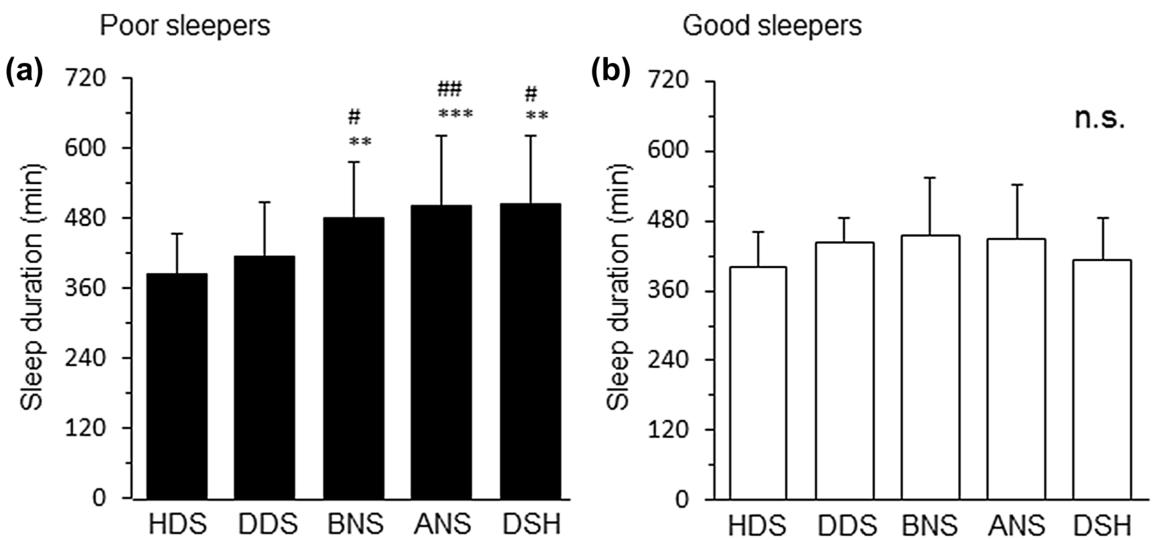

Fig. 2 Sleep durations following shift changes in nurses. **a** Sleep duration in poor sleepers. **b** Sleep duration in good sleepers. Comparisons of sleep durations between shift changes were performed using one-way ANOVAs followed by Tukey's tests. All values represent means ± standard deviations. $^{**}p < 0.01$, $^{***}p < 0.005$ for the significant difference from holiday to day shift; $^{\#}p < 0.05$, $^{\#\#}p < 0.01$ for the significant difference from day shift to day shift. *ns* nonsignificant

4 Discussion

We examined the relationships between nurses' habitual sleep quality, represented by subjective fatigue and sleep status, and changes in rotational-shift work. Although good sleepers adapted to changes in rotational shift-work patterns and recovered from fatigue despite limited sleep, subjective fatigue remained high in poor sleepers when their shift patterns included a day shift on the day following limited sleep duration. With respect to sleep duration, good sleepers reported stable sleep duration across all shift changes. However, in poor sleepers, sleep durations were longer prior to the BNS, ANS, and DSH shift changes, relative to those reported for the HDS and DDS shift changes.

Previous research has reported that nurses with good sleep quality who worked rotational shifts exhibited reductions in the accumulation of subjective fatigue [25]. In the present study, recovery from fatigue in poor sleepers was observed prior and subsequent to night-shift patterns and prior to holidays (i.e., BNS, ANS, and DSH shift changes) but not prior to day-shift patterns (i.e., HDS and CDS changes). Therefore, poor sleepers could reduce subjective fatigue by sleeping for longer durations when working the

BNS, ANS, and DSH shift changes. However, when shift changes were from day-shift to day-shift (i.e., HDS and DDS shift changes), poor sleepers could be unable to recover from fatigue resulting from insufficient sleep. Poor sleepers slept approximately 500 min prior and subsequent to night-shift patterns (i.e., BNS, ANS, and DSH shift changes), which was 2 h longer relative to their sleep durations prior to day-shift patterns (i.e., HDS and CDS shift changes). However, good sleepers displayed no differences in sleep durations across all shift changes. This difference in sleep durations between poor and good sleepers could be attributed to differences in sleep quality between the two groups. Good sleepers could recover from subjective fatigue resulting from short sleep durations, such as those prior to day-shift patterns (i.e., HDS and CDS shift changes), because of high sleep quality; however, with the same sleep durations, poor sleepers were unable to recover from their fatigue, because their habitual sleep quality was worse relative to that of good sleepers.

Kecklund et al. reported that apprehension at bedtime affected slow-wave sleep [34]. In the present study, scores for three components of the PSQI (sleep quality, sleep latency, and sleep efficiency) were significantly associated with STAI scores. Anxiety in poor sleepers was significantly higher relative to that observed in good sleepers, and high anxiety levels could affect sleep quality. In addition, nurses' work is known to be very stressful, which could increase the severity of anxiety and reduce sleep quality in poor sleepers. Other explanations for the finding could be that good sleepers were more resistant, relative to poor sleepers, or their work was less stressful relative to that of poor sleepers.

Many studies have examined adaptation to rotational-shift work in nurses [22, 23]. This adaptation has been reported to be influenced by several factors such as age, sex, chronotype, genotype, and light/darkness [19, 23, 24]. In the present study, there was no difference in age between poor and good sleepers. However, we could not exclude the possibility that differences in chronotype or genotype affected participants' adaptation to rotational-shift work. Indeed, differences in chronotype or genotype could have affected the severity of nurses' anxiety, which could have influenced their adaptation to rotational-shift work.

The study was subject to several limitations. First, we measured subjective, but not objective, fatigue based on VAS. Therefore, subjective fatigue on VAS might not fully reflect fatigue in this study. However, there is no commonly accepted objective measure of fatigue [35]. Furthermore, although fatigue measure was subjective in this study, fatigue scores in the same measure have been reported to correlate with autonomic nervous activity [32, 33] and functional connectivity in the brain [35]. In addition, shift-working nurses with high subjective fatigue on VAS displayed an increase of salivary cortisol level [36]. These findings suggest that subjective measure of fatigue on VAS reflects some functional changes of the body and/or brain. Further studies are required to assess fatigue objectively in night-shift nurses using other validated questionnaires and objective assessment (e.g., autonomic nervous activity, salivary cortisol, etc.). Second, we could not infer causation in the relationship between sleep quality and subjective fatigue in poor and good sleepers, because of the cross-sectional design of the study. Third, the sample sizes of the participants allocated by subjective sleep quality such as PSQI were small.

5 Conclusions

Good sleepers were able to recover from subjective fatigue despite shift changes. Although poor sleepers recovered from subjective fatigue with sufficient sleep duration, they could not do so with limited sleep duration prior to a day shift. The results suggest that it is important to ensure sufficient sleep duration according to individuals' sleep quality, to improve nurses' sleep quality and reduce their subjective fatigue. As subjective sleep quality was significantly correlated with anxiety, it is also important for nurses to relax sufficiently at bedtime and reduce anxiety, to maintain good sleep quality.

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References

1. Åkerstedt T, Torsvall L. Shift work: shift-dependent well-being and individual differences. Ergonomics. 1981;24:265–73.
2. Smith-Coggins R, Rosekind MR, Hurd S, Buccino KR. Relationship of day versus night sleep to physician performance and mood. Ann Emerg Med. 1994;24:928–34.
3. Åkerstedt T. Sleepiness as a consequence of shift work. Sleep. 1998;11:17–34.
4. Åkerstedt T. Shift work and disturbed sleep/wakefulness. Occup Med. 2003;53:89–94.
5. Mawdsley M, Grasby K, Talk A. The effect of sleep on item recognition and source memory recollection among shift-workers and permanent day-workers. J Sleep Res. 2014;5:538–44.
6. Vallières A, Azaiez A, Moureau V, LeBlanc M, Morin CM. Insomnia in shift work. Sleep Med. 2014;15:1440–8.
7. Chien PL, Su HF, Hsieh PC, Siao RY, Ling PY, Jou HJ. Sleep quality among female hospital staff nurses. Sleep Disord. 2013. https://doi.org/10.1155/2013/283490.
8. Josten EJ, Ng-A-Tham JE, Thierry H. The effects of extended workdays on fatigue, health, performance and satisfaction in nursing. J Adv Nurs. 2003;44:643–52.
9. Gu F, Han J, Laden F, Pan A, Caporaso NE, Stampfer MJ, Kawachi I, Rexrode KM, Willett WC, Hankinson SE, Speizer FE, Schernhammer ES. Total and cause-specific mortality of US nurses working rotating night shifts. Am J Prev Med. 2015;48:241–52.

10. Pan A, Schernhammer ES, Sun Q, Hu FB. Rotating night shift work and risk of type 2 diabetes: two prospective cohort studies in women. PLoS Med. 2011;8:e1001141.
11. Vyas MV, Garg AX, Iansavichus AV, Costella J, Donner A, Laugsand LE, Janszky I, Mrkobrada M, Parraga G, Hackam DG. Shift work and vascular events: systematic review and meta-analysis. BMJ. 2012;345:e4800.
12. Short MA, Agostini A, Lushington K, Dorrian J. A systematic review of the sleep, sleepiness, and performance implications of limited wake shift work schedules. Scand J Work Environ Health. 2015;41:425–40.
13. Kim MJ, Son KH, Park HY, Choi DJ, Yoon CH, Lee HY, Cho EY, Cho MC. Association between shift work and obesity among female nurses: korean Nurses' Survey. BMC Public Health. 2013;13:1204.
14. Ha M, Park J. Shiftwork and metabolic risk factors of cardiovascular disease. J Occup Health. 2005;47:89–95.
15. Ijaz S, Verbeek J, Seidler A, Lindbohm ML, Ojajärvi A, Orsini N, Costa G, Neuvonen K. Night-shift work and breast cancer—a systematic review and meta-analysis. Scand J Work Environ Health. 2013;39:431–47.
16. James FO, Cermakian N, Bovin DB. Circadian rhythms of melatonin, cortisol, and clock gene expression during simulated night shift work. Sleep. 2007;30:1427–36.
17. Lamond N, Dorrian J, Roach GD, McCulloch K, Holmes AL, Burgess HJ, Fletcher A, Dawson D. The impact of a week of simulated night work on sleep, circadian phase, and performance. Occup Environ Med. 2013;60:e13.
18. Boudrean P, Dumont GA, Boivin DB. Circadian adaptation to night shift work improves sleep, performance, mood, and the autonomic modulation of the heart. PLoS One. 2013;8:e70813.
19. Saksvik IB, Bjorvatn B, Hetland H, Sandal GM, Pallesen S. Individual differences in tolerance to shift work—a systematic review. Sleep Med Rev. 2011;15:221–35.
20. Boudreau P, Dumont GA, Boivin DB. Circadian adaptation to night shift work influences sleep, performance, mood and the autonomic modulation of the heart. PLoS One. 2013;8:e70813.
21. Storemark SS, Fossum IN, Bjorvatn B, Moen BE, Flo E, Pallesen S. Personality factors predict sleep-related shift work tolerance in different shifts at 2-year follow-up: a prospective study. BMJ. 2013;3:e003696.
22. Sato M, Yonezawa H, Ishizu M, Suga K, Ikemoto R. The relationship between cumulative fatigue and subjective feeling of sleepiness in nurses working three consecutive shifts. J Jpn Soc Nurs Health Care. 2002;4:28–35.
23. Gamble KL, Motsinger-Reif AA, Hida A, Borsetti HM, Servick SV, Ciarleglio CM, Robbins S, Hicks J, Carver K, Hamilton N, Wells N, Summar ML, McMahon DG, Johnson CH. Shift work in nurses: contribution of phenotypes and genotypes to adaptation. PLoS One. 2011;6:e18395.
24. Motsinger-Reif AA, Hida A, Borsetti HM, Servick SV, Ciarleglio CM, Robbins S, Hicks J, Carver K, Hamilton N, Wells N, Summar ML, McMahon DG, Johnson CH. Shift work in nurses: contribution of phenotypes and genotypes to adaptation. PLoS One. 2011;6:e18395.
25. Costa G, Anelli MM, Castellini G, Fustinoni S, Neri L. Stress and sleep in nurses employed in "3 × 8" and "2 × 12" fast rotating shift schedules. Chronobiol Int. 2014;31:1169–78.
26. Natvik S, Bjorvatn B, Moen BE, Magerøy N, Sivertsen B, Pallesen S. Personality factors related to shift work tolerance in two- and three-shift workers. Appl Ergon. 2011;42:719–24.
27. Matsumoto M, Lee B, Tozato F, Gennai K, Shiihara Y. Objective and subjective measures of sleep of shift-working nurses. Sangyo Eiseigaku Zasshi [J Occup health]. 2014;56:67–73.
28. Doi Y, Minowa M, Okawa M, Uchiyama M. Development of the Japanese version of the Pittsburgh sleep quality index. Jpn J Psychiatry Treat. 1998;13:755–63.
29. Johns MW. A new method for measuring daytime sleepiness: the Epworth sleepiness scale. Sleep. 1991;14:540–5.
30. Spielberger CD. Manual for the state-trait anxiety inventory. Palo Alto: Consulting Psychologists; 1983.
31. Ellis BW, John MW, Lancaster R, Raptopoulos P, Angelopoulos N, Priest RG. The St. Mary's hospital sleep questionnaire; a study of reliability. Sleep. 1981;4:93–7.
32. Mizuno K, Tanaka M, Yamaguti K, Kajimoto O, Kuratsune H, Watanabe Y. Mental fatigue caused by prolonged cognitive load associated with sympathetic hyperactivity. Behav Brain Funct. 2011;7:17.
33. Mizuno K, Tajima K, Watanabe Y, Kuratsune H. Fatigue correlates with the decrease in parasympathetic sinus modulation induced by a cognitive challenge. Behav Brain Funct. 2014;10:25.
34. Kecklund G, Åkerstedt T. Apprehension of the subsequent working day is associated with a low amount of slow wave sleep. Biol Psychol. 2004;66:169–76.
35. Nordin LE, Moller MC, Julin P, Bartfai A, Hashim F, Li TQ. Post mTBI fatigue is associated with abnormal brain functional connectivity. Sci Rep. 2016;6:21183.
36. Baba M, Ohkura M, Koga K, Nishiuchi K, Herrera CLR, Matsusue R, Inoue T. Analysis of salivary cortisol levels to determine the association between depression level and differences in circadian rhythms of shift-working nurses. J Occup Health. 2015;57:237–44.