Impact of nurse-assisted patient turning at different sleep stages on the quality of subsequent sleep *

Hisayoshi Sugawara, Ayumi Amemiya, Ryutaro Kase, Mariko Masujima, Ikuko Sakai, Yuji L. Tanaka, and Masatoshi Komiyama

Abstract— **Background: Nursing care performed during sleep, including nurse-assisted patient turning, is one of the factors that deteriorates sleep quality but is necessary for pressure ulcer prevention. Thus, it is important to determine when nurse-assisted patient turning has the least impact on sleep quality.**

Aim: The aim of this study was to clarify the impact of nurse-assisted patient turning at different sleep stages and to determine the optimal timing of this aspect during sleep.

Methods: The experiment, which consisted of healthy men in their 20s and 30s, was performed over four successive nights per subject. The first night was dedicated to environment adaptation, and the 2nd to the 4th nights were randomly assigned for shallow sleep intervention, deep sleep intervention, and non-intervention. On the intervention day, nurse-assisted patient turning was conducted twice. Overnight sleep conditions were measured by polysomnography (PSG). The PSG waveform transmitted to a tablet was analyzed in real time to determine the stage of sleep. The patient was turned when he entered the planned stage of sleep.

Results: The study analyzed fourteen (14) subjects. Shallow sleep time, deep sleep time, and sleep resumption time after nurse-assisted patient turning were compared among the three groups of non-intervention day, shallow sleep intervention day and deep sleep intervention day. There was no significant difference in the shallow and deep sleep time among the three groups. However, sleep resumption time after nurse-assisted patient turning was significantly shorter on the deep sleep intervention day than on the shallow sleep intervention day (p = 0.033).

Conclusions: This study has novelty in examining the impact of nurse-assisted patient turning performed at different sleep stages on subsequent sleep using objective indicators. The study suggested that a deep sleep state is the optimal timing of nurse-assisted patient turning due to the short time to sleep resumption.

I. Background

It has been reported that nursing care performed during sleep, including nurse-assisted patient turning, is one of the factors that lower sleep quality [1]. Despite nurse-assisted patient turning negatively affecting sleep quality, it is necessary for the prevention of pressure ulcers.

In a study using an automatic turning air mattress, it was reported that high sleep quality was observed compared to when a conventional mattress was used in patients for a home-care setting and a long-term care [2]. The authors said that the automatic turning air mattress has a possibility to reduce the burden of caregivers. However, there is no evidence that the automatic turning is sufficient. Thus, the guidelines indicated that the nurse (caregiver) -assisted patient turning is needed [3].

Sleep deprivation has various adverse effects on the body. For example, it affects blood pressure and heart rate by causing abnormal balance of autonomic nerves [4-6], leads to deterioration of immune function [7] and endocrine function [8], and even causes psychoneurotic symptoms [9]. Therefore, it is of much importance that a nurse-assisted patient turning method with less impact on sleep is determined.

Sometimes, the same patients will respond differently to nurse-assisted patient turning during sleep. There was a case in which a patient went to sleep immediately after awakening on one day; however, the same patient had difficulty resuming sleep upon being awakened despite the same manner of the intervention on the following day. These were often experienced in clinical setting. It has been known that the continuation of an awake state and insomnia may impact a patient's sleeping pattern resulting in day and night reversal and delirium. Based on these experiences, the timing of nurse-assisted patient turning, with minimum impact on sleep, must be determined.

Sleep stages are defined by rapid eye movement (REM) and non-rapid eye movement (NREM) stages. Furthermore, NREM is subdivided into four stages of S1, S2, S3, and S4 according to the depth of sleep and deepens from S1 to S4. S1 and S2 are classified as shallow sleep, and S3 and S4 are classified as deep sleep. It is also clear that there is an arousal threshold, which is a threshold of susceptibility during sleep. Although the arousal threshold is not constant in REM, in NREM, the arousal threshold increases as the sleep deepens from S1 to S4 [10]. In other words, the arousal threshold is the highest in S4, and it has been shown to be difficult to wake up in S4. Therefore, it is thought that different responses could be obtained by nurse-assisted patient turning in either shallow or deep sleep with different arousal thresholds.

The aim of this study was to characterize the impact of nurse-assisted patient turning at different sleep stages on the quality of subsequent sleep and to determine the optimal timing of nurse-assisted patient turning during sleep.

*Research supported by A Grant-in-Aid for research of Japan Nursing School Benefit Association.

H. Sugawara, A. Amemiya, R. Kase, Y.L. Tanaka, and M. Komiyama are from the Department of Nursing Physiology, Graduate School of Nursing, Chiba University, 1-8-1 Inohana, Chuo-ku, Chiba-shi, Chiba 260-8672 JAPAN (email: amemiya-a@chiba-u.jp).

M. Masujima is from the Department of Adult Nursing, Graduate School of Nursing, Chiba University.

I. Sakai is from the Department of Department of Nursing System Management, Graduate School of Nursing, Chiba University.

II. Methods

Subjects in this cross over trial were healthy men in their 20s and 30s who did not work at night or have any diagnosed sleep disorders. The experiment was performed in a controlled environment over four consecutive nights wherein the temperature was maintained at 25°C and humidity at 50%. After the first night, which was for environment adaptation, subjects were randomly assigned to shallow sleep intervention, deep sleep intervention, and non-intervention across the following three nights (Table I). On the intervention day, nurse-assisted patient turning was conducted twice with the cooperation of research collaborators (nurses). The time in bed (TIB) of the subject was 7 h 30 min per night.

In this study, polysomnography (PSG) (SOMNO-touch RESP PSG-LM: FUKUDA DENSHI, Japan) was used to measure the sleep stage as objective indicators (Figure 1). This lightweight (64 g) and small [84 (W) × 18 (L) × 55 (H) mm] device was equipped with a battery so that it could be easily transported. The data, consisting of a 256 Hz electroencephalogram, was transmitted to a dedicated tablet by Bluetooth communication, and a real-time waveform was confirmed. The wireless connectivity between the device and the tablet enabled unobstructed patient turning. The electrodes were attached at ground (GND), frontal polar (F1), vertex (Cz), central (C3), occipital (O1), and auricular (A2) sites, which were the standard electrode attachment sites in the international 10–20 method. One sleep stage, called an epoch, was determined every 30 s. The sleep stage was classified according to the Rechtschaffen and Kales method into six stages of wake, NREM (S1, S2, S3, S4) and REM.

Nurse-assisted patient turning was performed by two collaborators who were registered nurses. To be consistent, the same assistant performed the nurse-assisted patient turning for individual subjects. Overnight sleep conditions were measured by the PSG. The researcher judged a sleep stage based on the PSG waveform transmitted to the tablet in real time. The timing of shallow sleep intervention was decided as S2, and the timing of deep sleep intervention was decided as S3 or S4. The patient was turned when a sleep stage of the subject reached the planned sleep stage. The sleep latency was decided as the time until S2.

Descriptive statistics were used to represent the basic information of the subjects. To determine whether the order effect had an impact on the results, analysis was conducted among measurement days: the second, third, and fourth days. The variables that were compared were shallow sleep time, deep sleep time, REM time, wake time, sleep efficiency, bedtime, TIB, total sleep time (TST), and sleep latency (Figure 2).

To compare whether the measurement conditions differed significantly, analysis was conducted for the three groups: the shallow sleep intervention, deep sleep intervention, and non-intervention days. The variables that were compared via a one-way ANOVA were bedtime, TIB, TST, and sleep latency. A t-test was conducted between shallow sleep intervention and deep sleep intervention days for interval of nurse-assisted patient turning. A Fisher's exact probability test was conducted for the order of intervention day amongst the three groups: non-intervention, shallow sleep intervention day and deep sleep intervention day.

To compare responses due to differences in intervention, one-way ANOVA with post-hoc Tukey's test was conducted in the three groups for the variables shallow sleep time, deep sleep time, REM time, wake time, sleep efficiency, and sleep resumption time after nurse-assisted patient turning. The interval between nurse-assisted patient turning and time to sleep resumption after nurse-assisted patient turning was compared between the two groups using the t-test: shallow sleep intervention and deep sleep intervention days. For statistical analysis, IBM SPSS Statistic ver. 24 was used, and the significance was set to $p < 0.05$.

TABLE I. RESEARCH SCHEDULE

1st night	2nd night	3rd night	4th night
Environment adaptation day	Randomly assigned as the non-intervention day, the shallow sleep intervention day, and the deep sleep intervention day		

Figure 1. Attached PSG while sleeping

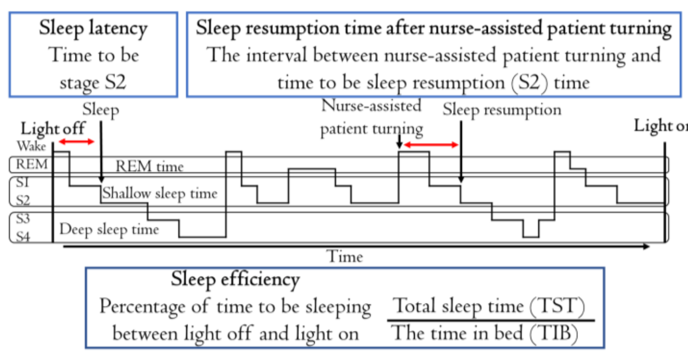

Figure 2. PSG measurement subjects

III. Results

Cooperation was obtained from 20 subjects. However, the real time sleep stage data of four subjects were misinterpreted. Thus, the scheduled intervention could not be conducted. A further two subjects were excluded due to insufficient deep sleep. Therefore, 6 subjects were excluded, and 14 subjects were analyzed (Table II).

For the comparison of the order effect of the measurement day, data for each variable was compared among the second, third, and fourth days. No significant difference was observed in the variables (Table III).

Measurement conditions were compared among the shallow sleep intervention, deep sleep intervention, and non-intervention days. No significant difference was observed in the variables. There was no significant difference between the shallow sleep intervention day group and deep sleep intervention day group with respect to the time interval between the two nurse-assisted patient turnings (Table IV).

Sleep resumption time after nurse-assisted patient turning on the shallow sleep intervention day was 7.5 ± 11.1 min, whereas that on the deep sleep intervention day was 3.6 ± 3.0 min. Thus, the sleep resumption time on the deep sleep intervention day was significantly shorter than that on shallow sleep intervention day (p = 0.033) (Table V).

Responses due to differences in intervention were compared among the shallow sleep intervention, deep sleep intervention, and non-intervention days. A significant difference was observed in REM time (p = 0.022), but no significant differences were observed in other variables. A posterior test showed a significant difference (p = 0.017) in the REM time between the non-intervention (98.9 ± 19.7 min) and shallow sleep intervention days (77.5 ± 20.0 min). However, there was no significant difference between the non-intervention and deep sleep intervention days (p = 0.312) and between the shallow sleep intervention and deep sleep intervention days (p = 0.342). Therefore, the REM time of the shallow sleep intervention day was significantly shorter than that of the non-intervention day (Table V).

The sleep resumption time in the shallow sleep intervention day took 2.1 times longer than in the deep sleep intervention day (Table VI).

TABLE II. SUBJECTS DATA

	Mean±SD
Subjects	14
Age (Year)	22.0 ± 1.6
Height (cm)	174.4 ± 6.1
Weight (kg)	63.1 ± 5.7
Body mass index	20.8 ± 1.9
Habitua Bedtime	0:47 ± 0:51
Habitua Wake-up time	7:47 ± 1:04
Habitual sleep time	7h2m ± 46m
Smoking habits	None
Exercise frequency	Average 2.9 times/ week (0-7Times)

TABLE III. COMPARISON OF MEASUREMENT DAY

	2nd night	3rd night	4th night	p-value
Shallow sleep time (m)	252.0 ± 29.9	262.3 ± 19.6	263.9 ± 16.7	0.335
Deep sleep time (m)	63.8 ± 22.1	61.4 ± 19.2	61.9 ± 16.1	0.943
REM time (m)	89.9 ± 28.2	84.0 ± 16.7	90.4 ± 17.1	0.677
Wake time (m)	46.4 ± 38.1	39.2 ± 16.6	36.4 ± 13.5	0.563
Sleep efficiency (%)	89.7 ± 8.4	91.2 ± 3.6	92.0 ± 3.0	0.565
Bedtime	23:04 ± 0:12	23:06 ± 0:10	23:00 ± 0:11	0.333
TIB (m)	452.0 ± 2.7	446.8 ± 17.9	452.6 ± 6.0	0.318
TST (m)	405.6 ± 38.3	407.6 ± 22.3	416.2 ± 14.5	0.549
Sleep latency (m)	18.5 ± 14.6	13.4 ± 6.6	13.4 ± 11.2	0.405

One-way ANOVA Mean ± SD
TIB: Time in bed TST: Total sleep time

TABLE IV. COMPARISON OF MEASUREMENT CONDITIONS

		non-interventio	shallow sleep intervention	deep sleep interventio	p-value
Bedtime		23:03 ± 0:09	23:02 ± 0:14	23:05 ± 0:09	0.855 1)
TIB (m)		452.2 ± 6.0	451.6 ± 2.1	447.7 ± 18.3	0.511 1)
TST (m)		417.1 ± 14.2	401.3 ± 38.7	411.1 ± 20.0	0.292 1)
Sleep latency (m)		14.6 ± 10.7	15.0 ± 11.3	15.8 ± 12.6	0.961 1)
Interval of nurse-assisted patient turning (m)		-	51.7 ± 30.1	53.6 ± 27.9	0.859 2)
Order of intervention day	2nd night	4(28.6%)	6(42.8%)	4(28.6%)	0.955 3)
	3rd night	5(35.7%)	4(28.6%)	5(35.7%)	
	4th night	5(35.7%)	4(28.6%)	5(35.7%)	

Mean ± SD
1)One-way ANOVA, 2)paired t tests , 3)Fisher's exact probability test
TIB: Time in bed TST: Total sleep time

TABLE V. COMPARISON OF RESPONSES AMONG DIFFERENT INTERVENTIONS

	non-interventio	shallow sleep intervention	deep sleep interventio	p-value
Shallow sleep time (m)	252.5 ± 18.0	263.2 ± 30.4	262.5 ± 18.0	0.392 1)
Deep sleep time (m)	65.7 ± 21.9	60.6 ± 15.5	60.7 ± 19.4	0.724 1)
REM time (m)	98.9 ± 19.7	77.5 ± 20.0	88.0 ± 18.9	0.022 *1)
Wake time (m)	35.1 ± 12.4	50.3 ± 38.6	36.5 ± 13.0	0.209 1)
Sleep efficiency (%)	92.2 ± 2.8	88.9 ± 8.5	91.9 ± 2.8	0.211 1)
Sleep resumption time (m)	-	7.5 ± 11.1	3.6 ± 3.0	0.033 *2)

Mean ± SD *p<0.05
1)One-way ANOVA, 2)paired t tests
Sleep resumption time: Sleep resumption time after nurse-assisted patient turning

TABLE VI. SLEEP RESUMPTION TIME OF EACH SUBJECTS

Subjects	shallow sleep intervention(m)	deep sleep intervention(m)	shallow sleep intervention / deep sleep intervention
1	3.5	2.5	1.4
2	2	5.5	0.4
3	8	2.5	3.2
4	13	4.0	3.3
5	7	3.5	2.0
6	17	12.0	1.4
7	8	8.0	1.0
8	4	8.0	0.5
9	14.5	8.5	1.7
10	43.5	17.0	2.6
11	8.5	7.5	1.1
12	66	12.0	5.5
13	3.5	5.0	0.7
14	11.5	5.5	2.1
Mean	15	7.3	2.1

IV. DISCUSSION

The study suggested that a deep sleep state is the optimal timing for nurse-assisted patient turning due to the short to sleep resumption time.

The variables were compared among the second, third, and fourth days. The variables were shallow sleep time, deep sleep time, REM time, wake time, sleep efficiency, bedtime, TIB, TST, and sleep latency. There were no significant differences in all variables, i.e., the measurement days did not have an effect.

It was also confirmed that there were no significant difference in all variables for measurement conditions among the measurement days. It was suggested that the measurement conditions did not significantly affect the results.

In the present study, sleep resumption time on the deep sleep intervention day was significantly shorter than that on the shallow sleep intervention day. Even after subjects were awakened by nurse-assisted patient turning, sleep inertia, a strong drowsiness that occurs after awakening, is so strong in deep sleep that it increases the possibility of sleep resumption. Thus, the type of intervention had an impact on sleep resumption time after nurse-assisted patient turning, and it was suggested that the impact on sleep was kept to a minimum even after the deep sleep intervention.

In addition, sleep resumption time after nurse-assisted patient turning on the shallow sleep intervention day was 7.5 ± 11.1 min, whereas that on the deep sleep intervention day was 3.6 ± 3.0 min. The standard deviation of sleep resumption time for the shallow sleep intervention day was larger than the deep sleep intervention day. There were two subjects who recorded over 40 min for the sleep resumption time on the shallow sleep intervention day. On the deep sleep intervention day, the maximum sleep resumption time experienced by one subject was 15 min. The two data points longer than 40 min were excluded, and differences of data from the other twelve subjects were analyzed by the t-test. Sleep resumption time after nurse-assisted patient turning on the shallow sleep intervention day was 4.2 ± 3.8 min, whereas that on the deep sleep intervention day was 3.0 ± 2.0 min. It was determined that the sleep resumption time after the nurse-assisted patient turning on the shallow sleep intervention day sleep tended to be long ($p = 0.08$). Furthermore, this result represented a trend observed in all subjects. These data also support the suggestion that the impact on sleep was kept to a minimum even after the deep sleep intervention.

Regarding REM time, there was no significant difference between the non-intervention and deep sleep intervention days; however, there was a significant difference between the non-intervention and shallow sleep intervention days, i.e., the impact of nurse-assisted patient turning during the deep sleep intervention was small. Our study showed that the optimal timing of nurse-assisted patient turning was during deep sleep.

As the limitation of this study, the sleep cycle after turning was not analyzed. Because the aim of this study was to characterize the impact of nurse-assisted patient turning at different sleep stages on the quality of subsequent sleep. The nurse-assisted patient turning timings during varied every day between and among patients. Thus, this analysis was not included in the study objectives.

In this research, in order to collect data under less restrictive environment for the subjects, measurements were conducted using wireless devices. As the result, there was considerable noise in the data transmitted wirelessly leading to misinterpretation of sleep stages for some subjects (whose data were eventually excluded from the data analysis). When using wireless connection, electrical noise is easily mixed with the output waveform, which makes complicates determination of waveforms in some cases, e.g. the 4 subjects who were eliminated because their data was misinterpretated in real time due to electro-signal noise. Normally, when analyzing electroencephalogram, appropriate filtering is performed on the data recorded in electrode units before performing analysis so as not to mistake judgment by waveform change due to noise. However, in this study signal filtering could not be performed because the data was collected in real time and there was no filter available for this study. Furthermore, analysis of waveforms could not be done while the waveform was depicted on a stationary screen image. This is because for the purposes of this study it was necessary to analyze waveforms in real time so it was easy to misinterpret the sleep stages as waveforms appeared in real-time. However, there was no substitute method for the presently contemplated apparatus, and some data loss was inevitable. Two subjects with less deep sleep were likely to have failed to sleep enough because it was difficult for them to adapt to the environment.

In this study, PSG was used to collect basic data. It is impossible to use PSG for all hospitalized patients in the clinical setting. Therefore, in the future, it is necessary to establish a method to easily determine deep sleep by using various sensors. By combining these method and results of this study, it may be possible to apply nurse-assisted patient turning with less impact on patient sleep in the clinical setting.

V. Conclusion

This study has a novel method in examining the impact of nurse-assisted patient turning performed at different stages of sleep on the subsequent sleep using objective indicators. The deep sleep state was the optimal timing of nurse-assisted patient turning because it was associated with a shorter time to sleep resumption compared to patient turning during the shallow sleep state in healthy young adults. The results of this study could be the basis for higher quality of nursing care.

References.

[1] M. Ritmala - Castren, I. Virtanen, S. Leivo, K. M. Kaukonen, H. Leino-Kilpi, “Sleep and nursing care activities in an intensive care unit,” *Nurs Health Sci*, vol. 17, no.3, pp. 354-361, 2015.

[2] H.I. Melland, D. Langemo, D. Hanson, B. Olson, S. Hunter, "Clinical evaluation of an automated turning bed" *Orthop Nurs,* vol. 18, no. 4, pp. 65-70, 1999.

[3] The Japanese Society of Pressure Ulcers Guideline Revision Committee, "JSPU guidelines for the prevention and management of pressure ulcers (3rd Ed.)" *Jpn J PU*. vol. 16, no. 1, pp. 12-90, 2014.

[4] O. Tochikubo, A. Ikeda, E. Miyajima, M. Ishii, “Effects of insufficient sleep on blood pressure monitored by a new multibiomedical recorder,” *Hypertension*, vol. 27, no. 6, pp.1318-1324, 1996.

[5] J. S. Loredo, M. G. Ziegler, S. Ancoli-Israel, J. L. Clausen, J.E. Dimsdale, “Relationship of arousals from sleep to sympathetic nervous system activity and BP in obstructive sleep apnea,” *Chest*., vol. 116, no. 3, pp. 655-659, 1999.

[6] X. Zhong, H. J. Hilton, G. J. Gates, et al., “Increased sympathetic and decreased parasympathetic cardiovascular modulation in normal humans with acute sleep deprivation,” *J Appl Physiol*, vol. 98, no. 6, pp. 2024-2032, 2005.

[7] P. A. Bryant, J. Trinder, N. Curtis, “Sick and tired: does sleep have a vital role in the immune system? ,” *Nat Rev Immunol*, vol. 4, no. 6, pp. 457-467, 2004.

[8] K. Spiegel, R. Leproult, E. Van Cauter, “Impact of sleep debt on metabolic and endocrine function,” *Lancet*, vol. 354, no. 9188, pp. 1435-1439, 1999.

[9] B. B. Kamdar, D. M. Needham, N.A. Collop, “Sleep deprivation in critical illness: its role in physical and psychological recovery,” *J Intensive Care Med*, vol. 27, no. 2, pp. 97-111, 2012.

[10] M. A. Carskadon, W. C. Dement, “Normal human sleep: an overview,” vol. 4, *Principles and practice of sleep medicine*, 2005, pp. 13-23.