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

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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. The first night was assigned for environment adaptation, and the second, third, and fourth 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. The variables were shallow sleep time, deep sleep time, REM time, and sleep resumption time after nurse-assisted patient turning as objective indicators.

Results: The study analyzed fourteen 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 lowers sleep quality [1]. Despite nurse-assisted patient turning negatively affecting sleep quality, it is necessary for the prevention of pressure ulcers.

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 [2-4], leads to deterioration of immune function [5] and endocrine function [6], and even causes psychoneurotic symptoms [7]. Therefore, it is of much importance that a nurse-assisted patient turning method of less impact on sleep is determined.

Sometimes, the same patient 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 returning to 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 the awake state and insomnia may cause patient's sleeping pattern of reversed day and night and delirium. Based on these experiences, the timing of nurse-assisted patient turning, which minimizes the 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 N1, N2, N3, and N4 according to the depth of sleep and deepens from N1 to N4. N1 and N2 are classified as shallow sleep, and N3 and N4 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 N1 to N4 [8]. In other words, the arousal threshold is the highest in N4, and it is also shown to be difficult to wake up in N4. 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.

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%.

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After the first night, which was for environment adaptation, subjects were randomly assigned shallow sleep intervention, deep sleep intervention, and non-intervention for 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.

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		

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 afforded 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 (N1, N2, N3, N4) and REM.

Figure 1. Attached PSG while sleeping

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 N2, and the timing of deep sleep intervention was decided as N3 or N4. 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 N2.

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 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 time 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 $p < 0.05$.

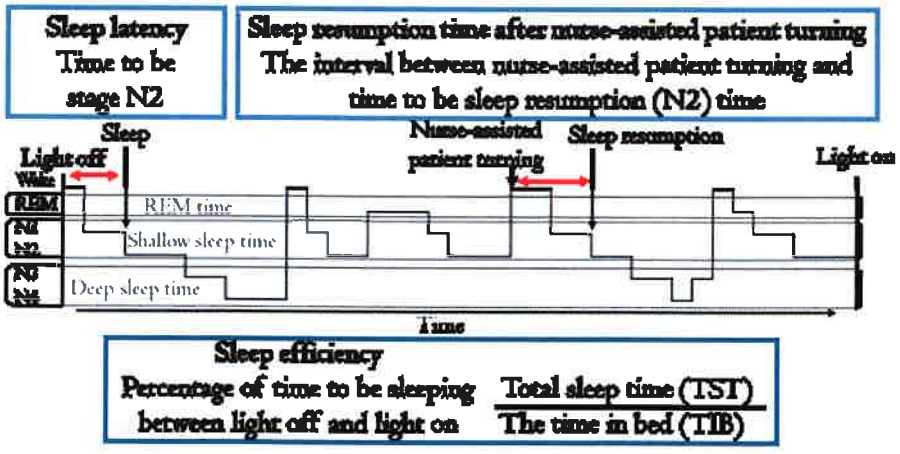

Figure 2. PSG measurement items

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III. Results

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

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)

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).

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

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 two groups shallow sleep intervention and deep sleep intervention days with respect to the time interval between the two nurse-assisted patient turnings (Table IV).

TABLE IV. COMPARISON OF MEASUREMENT CONDITIONS

		Non-intervention	Shallow sleep	Deep sleep intervention	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%)	
	3rd night	5(35.7%)	4(28.6%)	5(35.7%)	0.955 [3]
	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

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 (77.5 ± 20.0 min) days. 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 (Table V).

TABLE V. COMPARISON OF RESPONSES AMONG DIFFERENT INTERVENTIONS

	Non-intervention	Shallow sleep	Deep sleep intervention	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

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IV. Discussion

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.

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 difference 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 was large for the shallow sleep intervention but small for 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.

V. Conclusion

This study has novelty 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 the time to sleep resumption was shorter than that after intervention at the shallow sleep state in healthy young adults. The results of this study will be the basis for a higher quality of nursing care.

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