Influence of the Bathing Starting Time on Sleep in Winter

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The effects of the timing of daily bathing on sleep in winter were studied. Eight healthy male subjects were assigned to three sleep conditions: bathing just before sleeping (Condition J), bathing 2 h before sleeping (Condition T) and no bathing before sleeping (Control). We can found that slow wave sleep and REM sleep were increased, and sleep onset latency and wake after sleep onset were shortened in Condition T compared with Condition J. Rectal and mean skin temperatures in both bathing conditions were the same levels after the first half of sleep. Furthermore, subjective sleep sensation was the highest value in Condition T. These results suggest that bathing done before going to bed in winter was good for sleep; moreover, bathing 2 h before going to bed was more effective than bathing immediately before going to bed.

1. Introduction

There has been known in recent years that there is a relationship between passive body heating in a warm bath and sleep. It has been shown that there is an increase in slow wave sleep (SWS) during the early sleep period following hot water immersion in the afternoon or late evening (1, 2, 3). However, these studies were done with passive heating procedures for a long time and/or several times, hence it was different from daily bathing in Japan. Moreover, previous studies about effects of sleep following the timing of passive body heating have indicated results from comparison between very long time intervals (3, 4, 5). This study examines the physiological effect during sleep and subjective sleep estimation following two different timing of bathing in the evening before sleep, in order to suggest a right timing of daily bathing to get a more effective sleep in winter.

2. Materials and Methods

Eight healthy male students with a mean age of 22 years (range: 20–29 years) participated in the study. All participants were requested to not take any chemical stimulants (e.g. caffeine, medicine, alcohol, etc.) and to avoid excessive exercise or napping during the experimental period.

Bedroom temperature and relative humidity were respectively controlled at 10°C and RH50% to simulate the typical thermal conditions of a Japanese bedroom, and previous room was set up at 20°C and RH60% to simulate thermal conditions of a heating living room in winter. Participants were subjected to each of the following three sleep conditions: bathing just before sleeping (Condition J); bathing 2 h before sleeping (Condition T); no bathing before sleeping (Control). Subjects were required to immerse their bodies in hot water (40°C) up to the shoulder level for 20 min in both bathing

conditions.

The experiment extended over a 5-day period, with 2 adaptation nights and 3 experimental nights in random. Subjects attended the laboratory at 19:30 hr, and had the same kind of meal. They attached electrodes and sensors, changed to pajamas at 20:15 hr and they were led into a previous room at 21:00 hr. For Condition J, subjects took a bath from 23:20 to 23:40 hr, while subjects under Condition T were required to take a bath from 22:00 hr for 20 min and they went back to a previous room. Subjects were standing by from 21:00 hr to bedtime. Each subject was asked to retire at 23:50 hr, and the lights were turned off at 0:00 hr. They were woken up at 7:00 hr, and they completed a standard questionnaire about their night's sleep.

EEG (C3, C4, O1), EOG and EMG were monitored with an EEG recorder (EEG-5214, Nihon Kouden). Sleep polygraphs were analyzed at 30-sec epochs according to the standard criteria of Reftschaffen and Kales (6). A probe measuring the rectal temperature (Tre) was inserted 12 cm into the rectum of subjects. The skin temperature was measured at the forehead, abdomen, forearm, back of hand, thigh, calf and instep, and the mean skin temperature (Tsk) was calculated by Hardy and DuBois's seven-point method (7). Tre and Tsk were recorded at 1-min intervals using a thermistor data logger (LT8A, Gram Corp.). Subjective sleep sensations were derived from the OSA sleep questionnaire (8). For analyzing the statistic significance of the data, three-way and two-way ANOVAs were used. In addition, multiple comparisons between conditions were performed using the paired t-test. Differences of $p<0.05$ were considered significant for all statistical analyses.

3. Results

Sleep characteristics

Based on the results of the sleep parameters observed for each condition (Table 1). Compared with the other conditions, wake time was significantly ($p<0.01$) decrease and SWS was significantly ($p<0.05$) increased in Condition T. There was a significant difference ($p<0.05$) in the rapid eye movement (REM) sleep period between Condition J and T. Stage 1 showed a significant ($p<0.01$) increase under Control compared to the other conditions, however, stage 2 was significantly ($p<0.05$) decreased in Control. In addition, total sleep time and sleep efficiency were significantly ($p<0.05$) increased, sleep onset latency and wake after sleep onset were significantly ($p<0.05$) shortened under Condition T compared with the other conditions. Moreover, there was a significant ($p<0.05$) reduction of REM latency under Condition T.

Body temperature

Tre under Condition J and T were raised by bathing, and showed a significant ($p<0.05$) increase under Condition J compared to the other conditions until sleep after 3 h, significant ($p<0.05$) differences between Condition T and Control from 2:30 to 5:00 hr (Figure 1). At the time of lights-out (0:00 hr), there was a difference of Tre (more than 5°C) between Condition J and T. However, it disappeared gradually, the significant ($p<0.05$) differences among the two conditions showed only until 1:30 hr. On the other hand, Tsk at the time of lights-off was the highest value under Condition J, while the three conditions were equivalent 2 h after going to bed.

Table 1. Mean sleep variables under the three conditions: bathing just before sleeping (Condition J), bathing 2h before sleeping (Condition T) and non-bathing before sleeping (Control).

Average (SD) min

	Condition J	Condition T	Control
Total time of			
Wake **	27.38 (24.23)[a]	12.75 (12.22)[c]	31.81 (19.80)
REM *	56.69 (22.31)[a]	72.75 (25.04)	66.00 (14.77)
Stage 1 **	43.13 (14.39)[b]	36.56 (14.10)[c]	70.25 (9.09)
Stage 2 *	233.25 (28.97)[b]	221.81 (19.21)[c]	192.56 (27.63)
Stage 3	33.25 (17.10)	44.44 (12.27)	39.19 (13.58)
Stage 4	26.31 (23.51)	31.69 (15.55)	20.19 (20.69)
SWS (S3+S4) *	59.56 (16.74)[a]	68.63 (12.04)[c]	59.38 (24.76)
Sleep efficiency (%) **	93.48 (4.98)[a]	96.95 (2.91)[c]	92.13 (4.46)
Sleep onset latency (min)**	9.88 (6.28)[a]	3.81 (2.93)[c]	10.13 (5.06)
REM latency (min) *	136.56 (60.33)[a]	109.25 (49.30)[c]	135.44 (62.18)
First REM duration (min)	11.44 (7.04)	15.25 (7.25)	14.75 (10.84)
Wake after sleep onset (min)*	17.50 (16.03)[a]	8.94 (9.97)[c]	21.69 (17.91)

* $p < 0.05$, ** $p < 0.01$ in ANOVA.

a : Significant differences between Condition J and T

b : Significant differences between Condition J and Control

c : Significant differences between Condition T and Control

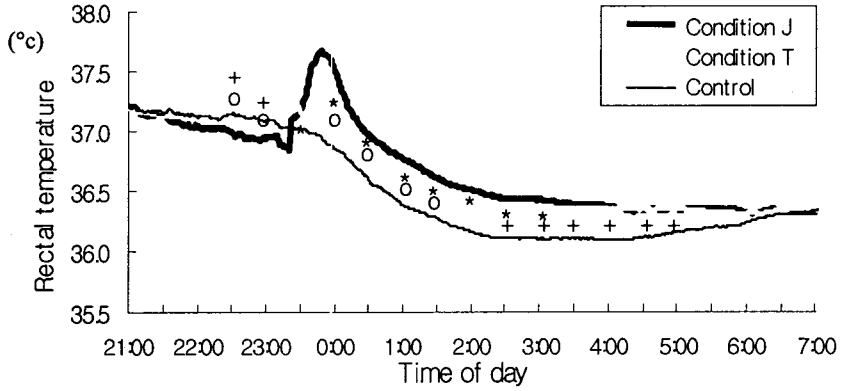

Figure 1. Changes in rectal temperature under three conditions. Statistical significance of Condition J vs Condition T (o ; $p<0.05$), Condition J vs Control (* ; $p<0.05$) and Condition T vs Control (+ ;$p<0.05$) were evaluated with *t*-tests.

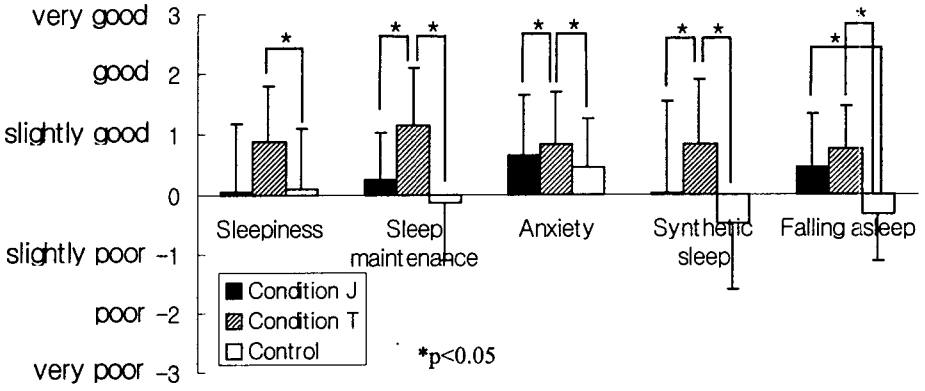

Figure 2. The five factors of OSA involving sleepiness in the morning, sleep maintenance, anxiety, synthetic sleep and falling asleep.

Subjective sleep sensation

Subjective sleep sensation gave the highest value in Condition T in all five factors (Figure 2). In particular, evaluation for factors related to sleep maintenance, anxiety and synthetic under Condition T was significantly ($p<0.05$) better than under the other conditions. The factor of falling asleep showed a significant ($p<0.05$) poor in Control compared to the other conditions.

4. Discussion

In this study, SWS was significantly increased under Condition T throughout the night (Table 1). This result corresponded with the study of Horne and Shackell which was taken a bath 2-3 h before going to bed (4). It is not clear why the SWS changes after body heating. However, there was an interpretation that it was caused by increase of brain temperature (9). The period of REM sleep was significantly shorter under Condition J (Table 1). This was largely due to a tendency in the subjects to miss the first REM period under Condition J. Bathing in hot water just before going to bed may have caused a strain on the sympathetic nervous system, which in turn may have caused an overall reduction in the amount of REM sleep (10).

Sleep onset latency was significantly shortened under Condition T compared to the other conditions, and the sleep efficiency tended to increase under Condition T (Table 1). The difference between Condition J and T may result because subjects are entering into sleep after Condition J with body temperature still elevated (3). Although Tsk of Condition J was the highest during early period of sleep, the best sleep parameters were indicated under Condition T. It was supposed that was caused by the nervous system after excessive increase of body temperature in Condition J. In Condition T, moreover, even if a rapid decline of Tre was not arisen in early period of sleep, the results of sleep quality got better compared with Condition J. Therefore, it was suggested that a rapid decline of Tre not always lead to good sleep.

5. Conclusions

These results suggest that bathing done before going to bed in winter was good for sleep. Moreover, SWS and REM were increased, sleep onset latency and wake after sleep onset shortened, and subjective sleep sensation was better in bathing 2 h before sleep more than bathing just before sleep. Furthermore, body temperatures of both bathing conditions were equivalent after the early sleep period. Therefore, bathing 2 h before going to bed was more effective than bathing immediately before going to bed.

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