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Effects of Timing of Warm Bathing on Night Sleep in Young Healthy Subjects

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Abstract Purpose: The purpose of the present study was to investigate the effects of timing of bathing on sleep. Methods: Data were obtained under three conditions of bathing (10 minutes in water of 40℃, body immersion up to neck) performed at 30 minutes, 1 hour and 2 hours before lying down to sleep. Polysomnographic data (EEG, EMG, EOG, and ECG) were recorded during sleep. Temperature of external auditory canal was measured before and after bathing and sleep. Sleep polygraphs were analyzed at every 20-second epoch interval according to the standard criteria of Rechtschaffen and Kales. The low frequency (LF: 0.04-0.15Hz) and high frequency (HF: 0.15-0.4Hz) components of heart rate variability (HRV), and LF/HF ratio of each five minutes from 22:00 to wake up were calculated from the power spectral analysis of R-R intervals. In addition, subjective feelings for sleep were assessed with Oguri-Shirakawa-Azumi (OSA) sleep profile answered by the participants immediately upon awakening. Results: Stage 3, stage 4 and slow wave sleep periods were significantly different ($p<0.05$ to <0.01) under three conditions. Under the condition bathing 2 hours before sleep, these periods were longest among different conditions. LF/HF ratio of HRV also significantly ($p<0.05$) differed under three conditions; this ratio was lowest under the condition bathing 2 hours before sleep, from 22:00 to 23:00 and from 3:00 to 4:00. Temperature of external auditory canal demonstrated significant differences ($p<0.05$ to <0.005) between different measurement times for all conditions. Scores for four out of five factors on subjective sleep measures showed significant differences ($p<0.05$ to <0.005) among three conditions. Compared to other conditions, the scores for condition 2 hours were highest. Conclusion: Bathing 2 hours before sleep appeared to be more effective in promoting better sleep quality than bathing 30 minutes or 1 hour before sleep.

Key words: bathing time, sleep polysomnograms, heart rate variability, external auditory canal temperature, sleep feelings

Introduction

Sleep coordinates with metabolism and internal secretory function of human body, and promotes brain activity and recovery from fatigue. Sleep has important role in normal cognitive and motor function. However, with complexity and diversification of the modern society, environments surrounding people are changing greatly, and numbers of individuals suffering from sleep disturbance are increasing. In a study of Bixler et al[1] among 1,000 people in Los Angeles, 42.5% were reported to have sleep disorder. American National Survey[2] found that 35% of the study population had sleep disorder. In contrast, a recent Japanese National Survey[3] reported sleep-related problems among 21.4% of the participants. A Japanese study by Kim et al,[4] investigating the relation between lifestyle and insomnia among 4,000 people, found that 22.3% men and 20.5% women suffered from insomnia.

Sleep disorder causes sleepiness or drowsiness, resulting in a fall of efficiency in daytime work. Such disorder is often associated with increased risk of accidents, chronic fatigue and fall in individual's quality of life.[5] Asai et al[6] using the survey data of Japanese Ministry of Health and Welfare carried out in 2000, examined the relation of sleep disorder with psychosomatic complaints. In this study, half of the population complained of various symptoms related to sleep disorder, such as difficulty in falling asleep, sleep maintenance, awakening early in the morning, insomnia, headache etc; women had more complaints than men.

Various physical, psychological and environmental factors influence sleep. Among different physical factors, body heating, physical exercise and bathing influence sleep. Usually bathing is done for personal hygiene and relaxation to alleviate fatigue. Several previous studies have shown the positive influence of short-duration bathing on sleep; body heating from bathing caused shortening of sleep onset latency and an increase in sleep quality.[7-11] The suitable temperature of water for bathing was shown to be around 40℃; also, short-duration bathing (20-30 minutes) was found to be more effective. In contrast, bathing at high temperature and for a long duration can cause adverse health effects like fall in blood pressure, tachycardia, decreased brain circulation, and thrombosis etc.[12-14]

Heat bath in the above-mentioned studies was taken at different time points; in most of the studies the time ranged from 20 minutes to several hours before going to bed.[7-11)15] It has been demonstrated that heat bathing significantly influences sleep quality, if performed at a time near sleep.[9-14] Currently, there is no general agreement regarding the timing of bathing before sleep. The purpose of the present study was to clarify the effects of timing of bathing on sleep.

Methods

Participants

Six healthy female students with a mean age 21.6±0.6 years, height 157.8±4.7 cm, body weight 50.5±4.8 kg and BMI 20.3±1.6 kg/m² volunteered in this study. Their menstrual cycle was follicular. All participants were informed about the objectives and methods of the study, and they gave written consent to participate. Before experiments, the first author questioned the participants regarding disease history, everyday sleep and drug use, and confirmed the absence of any disease causing sleep disorder. All participants were asked not to take medication or stimulants (e.g. caffeine, alcohol), and to avoid excessive exercise or sleeping at daytime during the course of the study. This study was approved by the Institutional Review Board of Yamaguchi University Hospital.

Environmental conditions

To simulate the typical thermal condition of a Japanese bedroom in summer, room temperature and relative humidity were controlled at 27±0.8℃ and 60±12.5% respectively. All the participants clothed in standard pajamas with short sleeves (100% cotton), and slept on mattress (wool/polyester: 50/50), layered with a sheet (100% cotton). While sleeping, the subjects covered their bodies with a comforter (100% cotton).

Procedures

The study was conducted over 3 consecutive days: 1 day for each condition of bathing (40 ℃ to under-neck level, 10 minutes) performed at 30 minutes, 1 hour and 2 hours before going to bed. The three experimental conditions were presented across the subjects using the Latin square design. Protocol of the experiment is depicted in Figure 1.

Same meals were given to all participants, and half an hour after dining at 18:00 in the laboratory, electrodes and sensors were attached to the corresponding recording sites on the body. Then each participant entered a previously prepared bedroom at 19:20 and laid in a bed for 20 minutes before bathing, when resting values were measured. Under the condition 30 min, the participants bathed 30 minutes before going to sleep at 22:00. Similarly under the condition 1h and the condition 2h, the participants bathed 1 hour and 2

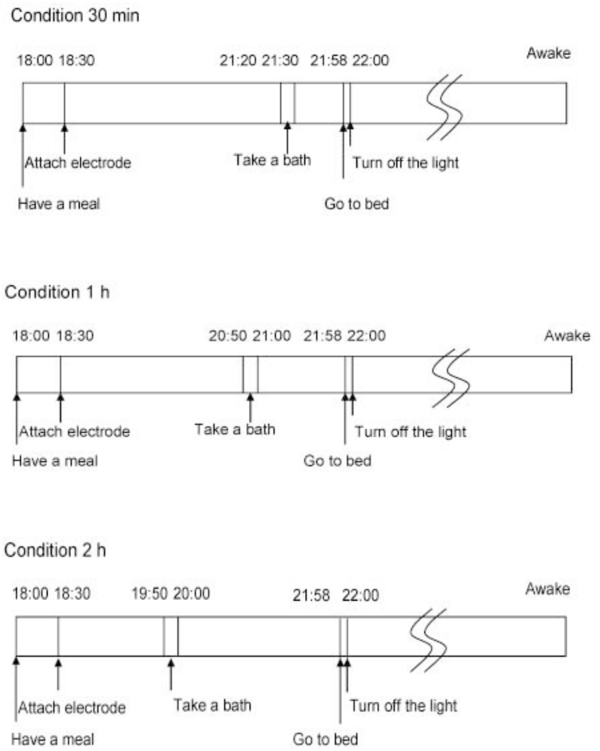

Fig. 1 Protocol of experiment (Condition 30 min: bathing at 30 minutes before sleep, Condition 1 h: bathing at 1 hour before sleep, Condition 2 h: bathing at 2 hours before sleep).

hours before going to bed. In the bath, participants were required to immerse their body up to the neck level for a period of 10 minutes. Immediately after bathing, they dried off using towel, and then drank 250 ml of water. During the spare time, participants relaxed and listened to music.

Consciousness level of each participant was monitored by a computer displaying electroencephalogram (EEG). On observation of changes in alpha wave, the examiner tapped on the shoulder of the subject to prevent from falling asleep. Each participant was asked to go to bed and to sleep at 21:58, and the lights were turned off at 22:00. During sleep, physiological data were recorded. On awakening at next morning, the participants were asked to evaluate their sleeping condition.

Measurements

Polysomnograms including EEG (C3, C4, O1), electrooculogram (EOG) electromyogram (EMG), and electrocardiogram (ECG) of the participants were monitored and recorded with a multi-telemeter (Multi Telemeter System WEB 5500, Nihon Kohden, Japan) from 18:00. Analysis of sleep polygraphs was performed at every 20-second epoch interval according to the standard criteria.[16] The manual, edited by Rechtschaffen and Kales, has been used worldwide in basic sleep research and also in clinical evaluation of sleep. According to the manual, wakefulness, REM (rapid eye movement) sleep, and non-REM sleep and its four stages are defined by three physiological variables, the EEG, the EOG, and the EMG.

The sleep parameters used in the present study are wake, movement time (MT), wake+movement (Wake+MT) time, rapid eye movement (REM) sleep, stage 1, stage 2, stage 3, Stage 4, slow wave sleep or SWS (slow wave sleep: stage 3 + stage 4), stage 3 in first cycle sleep, stage 4 in first cycle sleep, slow wave sleep or SWS (stage 3 + stage4) in first cycle sleep, total sleep time, sleep efficiency, sleep onset latency, rapid eye movement (REM) latency, stage 2 latency, stage 3 latency, and wake after sleep onset.[17] Sleep onset latency was calculated as the time interval from lights off (22:00) to sleep; stage 2 latency, stage 3 latency and REM latency were the time intervals from the first appearance of stage 1 to the first appearance of stage 2, stage 3 and REM respectively.

For the analysis of heart rate variability (HRV), the data were calculated using the software BIMUTASII (Kissei Comtec, Japan). The low frequency (LF: 0.04-0.15Hz) and high frequency (HF: 0.15-0.4Hz) components of HRV, and LF/HF ratio of every five minutes from 22:00 to wake up were calculated from the power spectral analysis of R-R intervals. LF power shows cardiac sympathetic and parasympathetic nerve activities; HF power shows cardiac parasympathetic nerve activity, and LF/HF ratio provides cardiac sympathetic nerve activity.[18]

As the core temperature, external auditory canal temperature at tympanic membrane was measured just before bathing, just after bathing, just before sleep (after lying down), and just after awakening.

To subjectively evaluate sleep quality, the Oguri-Shirakawa-Azumi(OSA) sleep profile[19] was used, which estimates psychologically the quality of sleep according to five different factors related to subjective sleep measures. This sleep profile consists of 31 items related to the subjective feelings of sleep, with a rating scale. Each item was evaluated with the maximum/minimum score, as mentioned in the OSA sleep questionnaire version 2.[19] The 29 items were classified to 5 factors, sleepiness, sleep maintenance, worries, integrated sleep feeling and sleep initiation.[19] Sleep sensation or quality of sleep is considered to be better, if the score on the questionnaire is higher. We received permission from the developers of the OSA sleep profile for using it in this study.

Statistical analysis

For HRV, data of every 5 minutes for each hour from 22:00 to 6:00 were calculated and averaged for that hour. From 5:00 to 6:00 at the condition 30min, HRV data were analyzed for 5 subjects, as one awoke at that time. Data are expressed in the text and tables as mean (±SD). Data on sleep parameters, subjective sleep feelings, and heart rate variability were analyzed using Friedman test. A value of $p<0.05$ was considered significant.

Results

Sleep characteristics

Sleep parameters observed for each condition are shown in Table 1. Stage 3 sleep period, stage 4 sleep period, and SWS period were significantly different under three conditions (stage 4, SWS: $p<0.05$; stage 3: $p<0.01$). Under the condition 2 hours, stage 3 sleep period, stage 4 sleep period, and SWS period were longest among three conditions.

But the time of REM sleep period, stage 1 sleep period and stage 2 sleep period did not exhibit significant differences for three conditions. In first cycle sleep, stage 3 sleep period, stage 4 sleep period, and SWS period were longest in the condition 2 hours, and there were no significant differences among three conditions.

The shortest value of total sleeping time among the 18 experiments of the six subjects was 465 min. For comparing sleep parameters between the first half and the latter half of sleep, the total sleeping time was divided into two blocks of the first and second 230 minutes each (Table 2). In both blocks there were significant ($p<0.05$) differences in stage 4 sleep

Table 1 Comparison of sleep parameters for whole night among three conditions (minutes)

	Condition 30 min	Condition 1 h	Condition 2 h	P value
Wake	41.7(16.5)	37.2(22.1)	22.7(10.1)	0.223
MT	2.3(0.3)	2.2(0.4)	2.1(0.5)	0.390
Wake+MT	44.0(16.5)	39.4(22.0)	24.8(9.9)	0.223
REM	83.0(12.4)	82.0(5.2)	81.0(8.0)	0.846
Stage 1	69.2(10.0)	79.7(13.6)	67.2(14.8)	0.311
Stage 2	276.7(57.3)	297.5(51.7)	267.2(28.7)	0.607
Stage 3	31.8(8.0)	31.0(8.4)	45.9(11.2)	0.009
Stage 4	11.1(4.9)	11.4(6.3)	22.4(4.3)	0.030
SWS	42.9(8.4)	42.4(13.5)	62.3(12.2)	0.042
Stage 3 in first cycle	3.4(1.5)	3.5(1.2)	9.2(5.7)	0.069
Stage 4 in first cycle	1.0(1.1)	1.2(1.67)	5.2(4.4)	0.172
SWS in first cycle	4.4(1.3)	4.7(2.7)	14.4(9.9)	0.135
Total sleep time	515.8(60.6)	540.9(65.1)	505.7(30.0)	0.607
Sleep efficiency (%)	91.3(3.6)	92.6(4.4)	95.1(2.0)	0.513
Sleep onset latency	31.0(17.4)	28.5(23.6)	16.6(11.3)	0.311
REM latency	51.6(20.1)	56.4(14.9)	78.9(28.1)	0.223
Stage 2 latency	10.2(4.0)	9.5(3.3)	14.0(6.6)	0.607
Stage 3 latency	47.1(21.3)	51.7(17.1)	64.5(24.9)	0.513
Wake after sleep	10.7(1.2)	8.7(2.5)	6.1(1.8)	0.015

Values are shown as mean (SD). n=6
P values indicate the statically significance level among three conditions by Freedman test.
Condition 30 min: bathing at 30 minutes before sleep, Condition 1 h: bathing at 1 hour before sleep, Condition 2 h: bathing at 2 hours before sleep, MT: movement time, SWS: slow wave sleep (Stage 3+Stage 4)

Table 2 Comparison of sleep parameters in first and second 230 minutes among three conditions (minutes)

	Condition 30 min	Condition 1 h	Condition 2 h	P value
First 230 min				
Wake	35.9(17.3)	33.0(22.9)	19.7(10.5)	0.311
MT	1.2(0.3)	1.3(0.4)	0.9(0.3)	0.086
Wake+MT	37.1(17.6)	34.3(22.6)	20.6(10.5)	0.311
REM	22.9(16.1)	28.8(14.7)	30.8(13.0)	0.513
Stage 1	34.1(5.1)	34.8(5.7)	33.1(9.0)	0.607
Stage 2	118.6(31.5)	117.7(24.9)	116.6(19.7)	0.607
Stage 3	10.9(4.4)	10.7(5.0)	18.2(7.8)	0.135
Stage 4	6.4(4.2)	3.8(1.1)	10.7(5.9)	0.036
SWS	17.3(8.1)	14.5(5.5)	28.9(12.2)	0.135
Second 230 min				
Wake	4.8(0.7)	2.7(2.3)	2.1(1.4)	0.032
MT	0.9(0.2)	0.9(0.3)	1.2(0.5)	0.264
Wake+MT	5.7(0.6)	3.6(2.2)	3.3(1.5)	0.070
REM	51.9(10.8)	39.6(16.1)	50.2(8.2)	0.607
Stage 1	30.1(4.5)	32.9(8.7)	25.3(3.6)	0.135
Stage 2	121.1(14.1)	132.7(21.6)	115.2(14.7)	0.154
Stage 3	16.6(6.4)	15.2(3.5)	23.8(7.8)	0.115
Stage 4	4.7(3.0)	5.6(2.3)	11.1(2.1)	0.015
SWS	21.3(8.5)	20.8(2.1)	34.8(6.2)	0.042

Values are shown as mean (SD). n=6
P values indicate the statically significance level among three conditions by Freedman test.
Condition 30 min: bathing at 30 minutes sleep, Condition 1 h: bathing at 1 hour before sleep, Condition 2 h: bathing at 2 hours before sleep, MT: movement time, SWS: slow wave sleep (Stage 3+Stage 4)

Table 3 Comparison of external auditory canal temperature change among three conditions (℃)

condition / time	Just before bathing	Just after bathing	Just before Sleep	Just after sleep	P value
Condition 30 min	37.2±0.6	37.7±0.8	37.0±0.4	36.5±0.4	0.004
Condition 1 h	37.1±0.5	37.5±0.7	36.8±0.5	36.7±0.5	0.012
Condition 2 h	37.0±0.3	37.4±0.6	37.4±0.6	36.4±0.4	0.006
P value	0.873	0.554	0.094	0.291	

Values are shown as mean ± SD. n=6
Condition 30 min: bathing at 30 minutes before sleep, Condition 1 h: bathing at 1 hour before sleep, Condition 2 h: bathing at 2 hours before sleep, Horizontal P values: comparison among eight blocks (time), Vertical P values: comparison among three conditions

Table 4 Comparison of heart rate variability change among three conditions ($msec^2$)

indicator	condition / time	22:00～23:00	23:00～0:00	0:00～1:00	1:00～2:00	2:00～3:00	3:00～4:00	4:00～5:00	5:00～6:00	P value
LF	Condition 30 min	2051±857	2809±881	2444±456	2621±861	3048±879	2904±958	3144±561	3175±434	0.104
	Condition 1 h	1892±735	2243±705	2472±468	3011±1101	3059±1145	3119±1085	2971±1531	3245±1226	0.041
	Condition 2 h	2098±623	2472±632	2532±960	2334±668	2799±824	2378±622	2387±843	2555±705	0.687
P value		0.956	0.607	0.607	0.129	0.115	0.846	0.538	0.538	
LF	Condition 30 min	2700±1488	4119±1976	3384±811	3924±1277	4895±1749	5012±1701	5233±894	4638±1175	0.013
	Condition 1 h	3463±505	3654±1351	3768±1339	4606±2010	4397±1714	4552±1796	4205±1669	4835±1389	0.226
	Condition 2 h	5765±1114	4357±778	4731±1949	3819±1278	4321±1818	3918±1283	4703±2447	4209±1295	0.323
P value		0.084	0.607	0.568	0.154	0.878	0.311	0.438	0.401	
LF/HF	Condition 30 min	0.96±0.52	1.10±0.80	0.87±0.33	0.86±0.39	0.75±0.25	0.77±0.27	0.66±0.13	0.78±0.22	0.619
	Condition 1 h	0.66±0.14	0.69±0.14	0.75±0.26	0.76±0.18	0.74±0.15	0.82±0.20	0.75±0.16	0.69±0.10	0.212
	Condition 2 h	0.47±0.15	0.67±0.12	0.6±0.10	0.68±0.54	0.76±0.22	0.68±0.15	0.74±0.27	0.69±0.24	0.706
P value		0.042	0.311	0.311	0.878	0.846	0.030	0.438	0.065	

Values are shown as mean ± SD. n=6
Condition 30 min: bathing at 30 minutes before sleep, Condition 1 h: bathing at 1 hour before sleep, Condition 2 h: bathing at 2 hours before sleep, Horizontal P values: comparison among eight blocks (time), Vertical P values: comparison among three conditions

period among all conditions. Moreover, there was a significant difference ($p<0.05$) in SWS period in second 230 minutes between three conditions, whereas in first 230 minutes, no significant difference was obtained for that period. Also, there was a significant ($p<0.05$) difference for wake in second 230 minutes among three conditions.

External auditory canal temperature

Changes of external auditory canal temperature are shown in Table 3. For all conditions, there were significant differences in external auditory canal temperature among different measurement times (Condition 30 min: $p<0.005$, Condition 1 h: $p<0.05$, Condition 2 h: $p<0.01$). External auditory canal temperature just after bathing were 0.4〜0.5℃ higher than external auditory canal temperature just before bathing in all conditions. When participants took a bath at one hour or 30 minutes before sleep, external auditory canal temperature of just before sleep decreased by 0.2〜0.3℃ compared with external auditory canal temperature of just before bathing. On the other hand, when participants took a bath at two hours before sleep, external auditory canal temperature of just before sleep increased by 0.4℃ compared with external auditory canal temperature of just before bathing.

Heart rate variability

Figure 2 shows the changes in mean power of HRV. The LF power of HRV did not change largely with time; but the LF/HF ratio and the HF power of HRV showed considerable changes after the onset of sleep. Therefore, to indicate any difference, hourly changes in HRV were compared among different conditions (as shown in Table 4). Under the condition bathing 1 hour before sleep, LF values of heart rate variability were significantly different among the eight periods ($p<0.05$). Under the condition of bathing 30 minutes before sleep, HF of heart rate variability was significantly different among the eight periods ($p<0.05$). Though not statistically significant, the value of HF was highest under the condition of bathing 2 hours before sleep. From 22:00 to 23:00 and from 3:00 to 4:00, the values for LF/HF ratio of heart rate

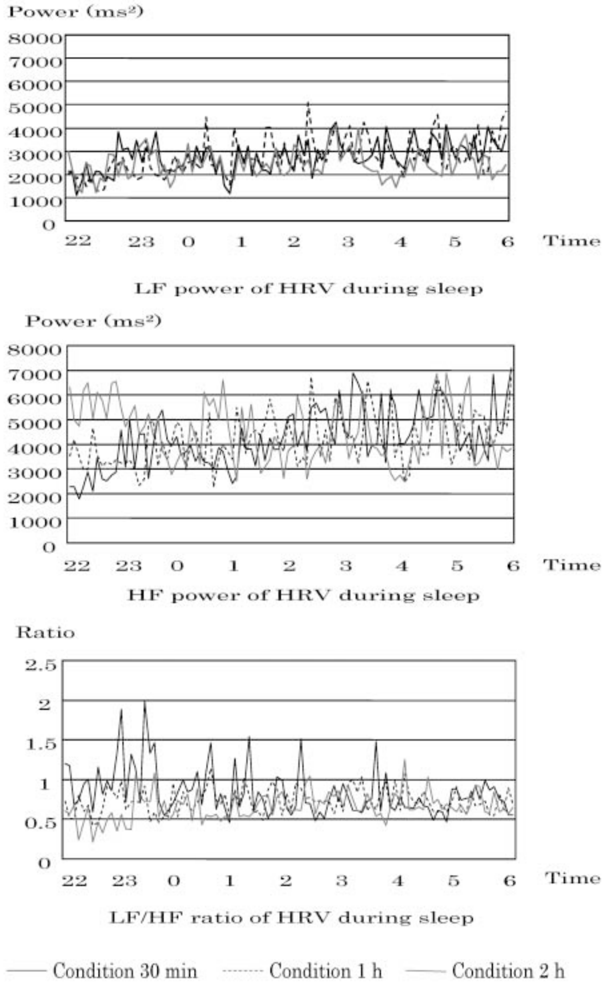

Fig. 2 Changes in mean power of heart rate variability (n=6, Condition 30 min: bathing at 30 minutes before sleep, Condition 1 h: bathing at 1hour before sleep, Condition 2 h: bathing at 2 hours before sleep).

variability significantly differed among thee conditions ($p<0.05$), and the value for bathing 2 hours before sleep was lowest among these conditions.

Subjective sleep measures

Standardized scores derived with OSA sleep profile are depicted in Figure 3. The scores for sleepiness, sleep maintenance, worries, and integrated sleep feeling were significantly different among three conditions (sleepiness: $p<0.01$, sleep maintenance: $p<0.005$, worries: $p<0.05$, integrated sleep feeling: $p<0.001$); the scores for condition 2 hours were higher than conditions 30 minutes and 1 hour. But the scores for falling asleep were not signifi-

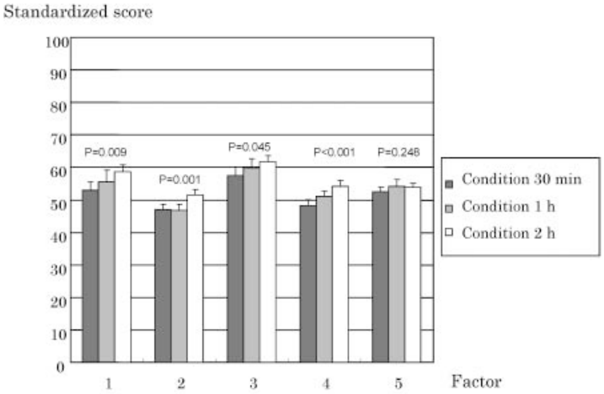

Fig. 3 Standardized score of OSA sleep profile (mean ± SD, n=6, Condition 30 min: bathing at 30 minutes before sleep, Condition 1 h: bathing at 1hour before sleep, Condition 2 h: bathing at 2 hours before sleep, Factor 1: sleepiness, Factor 2: sleep maintenance, Factor 3: worries, Factor 4: integrated sleep feeling, Factor 5: sleep initiation , P values indicate the difference between three conditions).

cantly different among three conditions.

Discussion

It has been pointed out that time interval between warm bathing and sleep may affect sleep efficiency;[9,15] but it is not clear, what interval is effective for a better quality sleep. To clarify this, we compared three conditions of interval between warm bathing (at 40℃, 10 minutes) and sleep, such as 30 minutes, 1 hour and 2 hours, on sleep efficiency.

As observed in the present study, on bathing at 2 hours before sleep, stage 3 and stage 4 sleep periods and SWS period significantly increased, when comparing with other conditions. Several studies examined the influence of body heating on sleep and emphasized the patterns of changes in sleep periods. Horne and Reid[8] mentioned that a suitable heat bathing (41℃, 90 minutes) induced significant increases in SWS period and stage 4 sleep period, compared with slight heat bathing (35.5℃, 90 minutes). In another study, Horne and Shackell[9] examined the combined effect on SWS sleep period of body heating (41℃, 30 minutes) seven/eight hours or two/three hours before sleep, with aspirin or placebo intake about 3 hours before sleep. Heat bathing with aspirin intake did not elicit any significant change in sleep parameters. In contrast, while taking placebo, SWS period increased significantly only under the condition of bathing two/three hours before sleep. In study of Bunnell et al (1988),[15] it was observed that heating (41℃, 1 hour) in the evening (six hours before lights-off) decreased sleep latency. On the other hand, heating just before going to bed caused a decrease in REM sleep period, and increase in stage 4 sleep period and SWS period in the first sleep cycle. The findings of our study showing changes in different sleep stages are consistent with other studies.

From the above-mentioned studies, it is obvious that body heating from bathing has a large influence especially on SWS sleep period. Horne and Reid[8] hypothesized that a rise in body temperature by body heating causes an increase in the temperature and subsequently metabolism of the brain. All these processes influence prostaglandin D2 secretion promoting SWS period, and regulate body temperature through the activity of serotonin.[9,20]

In this study, in the case of condition 30 minutes or 1 hour before sleep, external auditory canal temperature just before sleep decreased after an earlier increase just after bathing, whereas similar decrease just after sleep was not observed for the condition two hours before sleep. However, these findings differ from Bunnel's findings,[15] who reported that core temperature and brain temperature rises if the time from body heating to sleep gets shorter. The reason for such discrepancy is not clear.

As shown in this study, under the condition of bathing 2 h before sleep, HF power of HRV was highest among 3 conditions indicating heightened parasympathetic activity at 22:00 to 23:00. Moreover, during this time under the same condition, LF/HF ratio of HRV was lowest and significantly different from the other conditions, which indicates lowered sympathetic nerve activity. Burgess et al[21,22] reported that autonomic activity was influenced by thermoregulatory mechanisms on sleep and sympathetic nervous activity was lowest at SWS period. This coincides with the observed findings in the present study, which shows LF/HF ratio of heart rate variability is lower and SWS period is longer under the condition of bathing 2 hours before sleep. However, no previous report is available demonstrating the effect of bath timing on HRV during sleep, making the comparison difficult.

Under all conditions, external auditory canal temperature, which is expected to reflect core temperature, just after bathing was highest and the temperature just after awakening was lowest. The mechanisms for interaction of body temperature changes with sleep are still unclear.[5] Muscle relaxation and fall in the metabolic rate are thought to lie behind the decrease of external auditory canal temperature observed during sleep.[23][24]

The quality of sleep was also better under the condition of bathing 2 h before sleep, as the scores of subjective sleep index derived from OSA sleep questionnaire were higher when comparing with other conditions. Fichtenberg et al[25] reported that sleep onset latency, sleep duration, and sleep efficiency were positively correlated with subjective sleep measures, evaluated using the PSQI (Pittsburgh Sleep Questionnaire Index). Although, the OSA questionnaire is different from the PSQI, it could be demonstrated that subjective sleep feeling and sleep parameters were influenced by the bath timing.

The study has limitations like small number of subjects and using only female subjects of younger age group. However, from the observed findings it may be concluded that bathing 2 hours before sleep influenced subsequent sleep more than bathing 30 minutes or 1 hour before sleep, and the former condition was also more effective in promoting the sleep of better quality.

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