

# THERMOREGULATION DURING SLEEP IN ELDERLY AND YOUNG PEOPLE

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## INTRODUCTION

Elderly people are generally less capable of maintaining their core body temperature when exposed to the cold or heat as compared to young individuals (Kenney, 2003). However, between old and young subjects no significant difference was observed with respect to preferred temperature determined by the individual's self-control (Taylor, 1995) and small difference was found in the thermoneutral temperature (Tsuzuki, 2003), although skin temperature responses differed between old and young subjects (Taylor, 1995; Tsuzuki, 2003). Sleep complaints related to difficulties in initiating and maintaining sleep increase with age because of frequent brief awakenings and short durations of slow-wave sleep (SWS) (Monk et al. 1991; Dorsey et al. 1999). It has reported that the amplitude of the circadian temperature rhythm is significantly lower in elderly subjects than in young men (Vitiello, 1986). The lower circadian amplitude and advanced phase observed in elderly people than in young people in the constant-routine study was probably attributable to both age-related change in circadian pacemakers and reduced homeostatic pressure for sleep (Dijk, 1999). Sleep quality is dependent on both the circadian rhythm and thermoregulation (Someren, 2000). Abundant research has been carried out with regard to sleep in elderly people as compared to that in young people. However, studies on thermoregulation during sleep in elderly people are few (Okamoto-Mizuno, 2004). The aim of the present study is to compare thermoregulation during sleep between healthy old and young individuals.

## METHODS

### Subjects

Twelve young and ten old male volunteers served as subjects. The physical characteristics of the subject groups were as follows: age  $25 \pm 3.8$  and  $69.2 \pm 1.4$  years; height  $171.2 \pm 4.5$  and  $162.2 \pm 3.6$  cm; weight  $62.5 \pm 6.9$  and  $60.3 \pm 5.6$  kg; and body surface area  $1.68 \pm 0.09$  and  $1.60 \pm 0.08$  m<sup>2</sup>, respectively. Each subject provided written consent after being informed of the study protocol. Physical examinations, morningness and eveningness questionnaire (Horne et al., 1976), a sleep questionnaire, and psychological tests were administered prior to the study. The results indicated that all subjects were physically and mentally sound.

## Conditions and procedure

The experiments were carried out from August to September in the adjoining two climate chambers. The subjects were asked to rest for two hours in the first chamber before being permitted to sleep under conditions consisting of air temperature ( $T_a$ ) and relative humidity (RH) maintained at 26 °C and RH 50% (ambient partial vapor pressure ( $P_a$ ) of 12.6 Torr; 26/50) in the second chamber. The subjects slept wearing briefs, short pants, and short sleeve pajamas (100% cotton) on a bed covered with a bed sheet (100% cotton) and a blanket (100% cotton). Clothing insulation was estimated to be 0.4 clo. The subjects came around 20:00 and donned pajamas after measurements of body weight. Electrodes were attached while the subjects remained seated in a chair. At 21:45, the elderly subjects moved to the second chamber and lay down on the bed, on top of the cotton sheet. After completing the last questionnaire before falling sleep, the subjects were allowed to sleep from 22:00 p.m. to 6:00 a.m. The young subjects moved to the chamber at 22:45 and they slept from 23:00 p.m. to 7:00 a.m.

## Physiological Measurements

EEG (C3-A2, C4-A1, O1-A2), EOG and mental EMG were recorded using a 14-channel EEG machine (EEG-4317, Nihon-Kohden). Sleep recordings were scored visually every thirty seconds based on the standard manual of Rechtschaffen and Kales (1968). Rectal temperatures ( $T_{re}$ ) were measured continuously with a thermistor probe (ITP 010-11, YSI) inserted 12 cm beyond the anus at intervals of thirty seconds. Local skin temperatures were continuously measured at 30 sec-intervals using a thermistor (ITP 010-12, YSI). The thermistors were attached to skin surfaces at the forehead, chest, arm, thigh, leg, and foot. Mean skin temperatures ( $T_{sk}$ ) were calculated according to Ramanathan (1964). The microclimate temperature and humidity inside the pajamas were measured at 30-sec intervals with a thermistor probe and a semiconductor relative humidity sensor (CHS-APS, TDK). A thermistor probe and humidity sensor were placed on a 5-mm-thick heatproof board, which was placed on the skin of the chest area under the pajamas. Overall body mass was measured before and after the sleep recording sessions, without pajamas, using a sensitive platform balance (ID3S, Mettler). Overall body weight loss was calculated from the two measurements of body mass taken before falling asleep and upon waking.

Table 1 Sleep parameters in old and young groups

	Old	Young	
Latency of (min)			
Sleep	11.3(6.3)	12.7(15.1)	
SWS	55.7(34.5)	15(4.3)	*
REM	76.1(21.1)	95.6(28.3)	
Total duration of (min)			
TIB	480(0)	480.3(1.1)	
SPT	447.9(32.9)	467.3(15.9)	
TST	368.8(32.5)	451.7(15.7)	
WASO	79.1(27.4)	16.1(7.3)	*
EMA	20.8(23.5)	0.3(0.7)	*
Percentage (%)			
W	17.6(5.3)	5.9(3.2)	*
S1	16.3(11.5)	8.7(3.7)	
S2	40.9(14.8)	49.9(9.4)	
S3	3.2(4.1)	6.9(3.4)	
S4	0.9(2.6)	8.2(4.9)	*
S3+S4	4.2(6.4)	15.1(7.3)	*
REM	21.1(6.8)	20.4(4.7)	
SEI(%)	82.4(6.1)	96.5(1.5)	*

## Statistical Analysis

Before statistical analysis, sleep onset latency was log transformed. T-test was used to analyze the effect of age on sleep parameters, overall weight loss, and sensations. One-way ANOVA for repeated measures was used to test local skin temperatures,  $T_{sk}$ ,  $T_{re}$ , microclimate

temperature and humidity through the night. Post hoc comparison was conducted to evaluate differences in time course between the two groups. The level of significance was  $p < 0.05$ .

## RESULTS

### Sleep parameters

The recorded sleep parameters are shown in Table 1. SWS latency was significantly longer in old subjects than in young subjects, although no significant differences were observed between the 2 subject groups with respect to sleep onset and rapid eye movement (REM) sleep latency. Wake after sleep onset (WASO) lasted for a significantly longer duration in old subjects than in young

subjects, although there were no significant differences between the 2 subject groups with respect to the total duration of time in bed (TIB), sleep period time (SPT), and total sleep time (TST). Each sleep stage was expressed as a percentage of the SPT. It was found that the bouts of wakefulness lasted for significantly longer durations, and the period of S4 sleep and SWS were significantly shorter in the old subjects than in the young subjects, although no significant differences were found between the 2 groups with respect to S1, S2, and S3 sleep, and REM. The sleep efficiency index was significantly lower in the old subjects than in the young subjects. In order to observe changes in sleep stage distribution during the night, the percentage of SPT was calculated separately for each 60-min period during all the sleep stages in Fig.1. The percentage of time spent in stage wake was significantly higher in the old subjects than in the young subjects between the 2nd and the 8th hour, although there were no significant differences between the 2 groups at the 1st hour.

Body temperature and whole-body sweat loss

The changes in Tre, chest, thigh, and foot Ts are

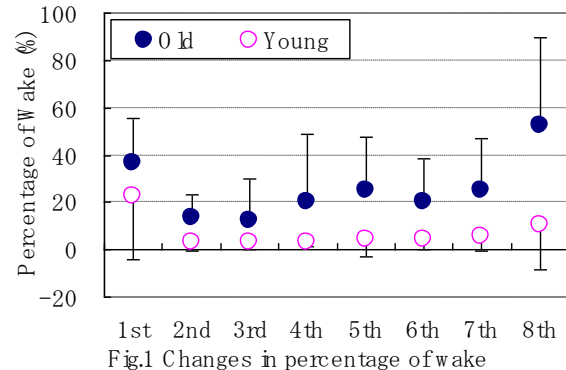


Fig.1 Changes in percentage of wake

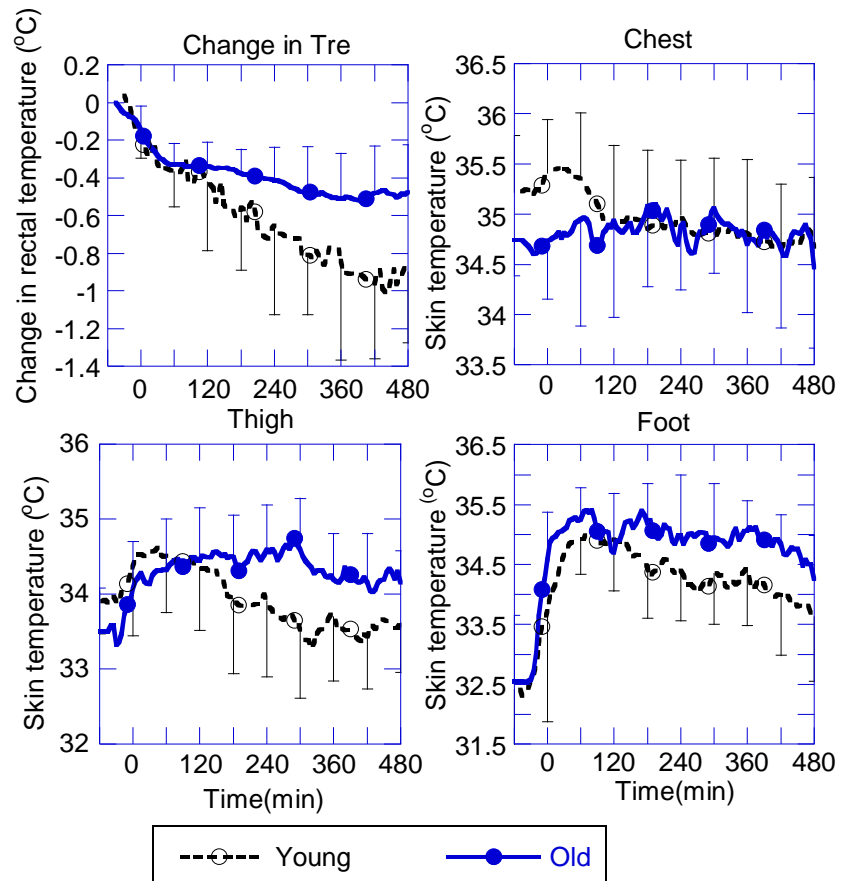


Fig.2 Tre change, chest, thigh, and foot Ts in young and old groups

shown in Fig. 1. In both old and young subjects, the Tre began to decrease before the lights were turned off. The Tre was significantly lower at 360 min, 420 min, and 480 min in the young subjects than in the old subjects ( $P < 0.05$ ). The decrease in Tre was significantly greater in the young subjects than in the old subjects from 120 min until the end of the sleep session. We could not identify the main effects of age on the microclimate or the mean skin temperature (Tsk) of the subjects. However, both the forehead and the chest Ts were significantly higher in young subjects than in old subjects at -60 min and at 0 min ( $P < 0.05$ ). The thigh Ts was significantly lower in the young subjects than in the old subjects at 300 min, 420 min, and 480 min ( $P < 0.05$ ). Among 10 of the old subjects, 3 urinated once during sleep. However, this was not observed in any of the young subjects. The urine volume was  $281.1 \pm 15.0$  ml (mean  $\pm$  standard deviation). The urine volume was excluded when calculating whole-body sweat loss. Whole-body sweat loss was significantly higher in the young subjects than in the old subjects ( $P < 0.05$ ). There were no significant differences between the 2 subject groups with respect to thermal and comfort sensations. Moreover, the subjective assessments of sleep or sleepiness did not significantly differ before and after the sleep session between old and young subjects.

## CONCLUSIONS

The results of the present study indicate that the old subjects in this study were normal healthy individuals because the results of sleep duration and sleep stage distribution of these subjects during the night are consistent with those obtained in previous studies on normal old individuals. In a previous study, it has been reported that the core temperature increases because of the timing of the early morning decrease in peripheral vasodilation and heat loss (Someren, 2000). In the present study, the peripheral Ts was considerably higher in the old subjects than in the young subjects in the latter part of the sleep session. However, the Tre in the old subjects did not decrease to the same extent as the Tre in young subjects but remained at a higher level. This may be attributable to a higher percentage of wakefulness in the old subjects through the night.

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