

Lower-limb warming improves sleep quality in elderly people living in nursing homes

Chika Oshima-Saeki ^{1*}

Yuiko Taniho ²

Hiroshi Arita ³

Etsuko Fujimoto ¹

¹ Department of Nursing, Nagoya University Graduate School of Medicine.

² Komatsu Nursing School.

³ Department of Nursing Science, Nursing and Social Welfare, Fukui Prefectural University.

ABSTRACT

Sleep disturbances are common in older people. This study was conducted to examine the effects of a hot pack, which was used to warm the lower limbs, on the sleep of elderly people living in a nursing home. This is a prospective cohort involving seven elderly women. Subjects aged 74–93 years old were treated by warming the lower limbs for 40 minutes using hot packs every night over 8 weeks. A hot pack made of a dense polymer and warmed in a microwave oven was used as a warming device. In the first and last week, the subjects were required to wear an activity monitor to determine their sleep–awake status. During the second to ninth week, they received limb-warming treatment by a hot pack heated to 42°C for 40 min every night. Surface skin temperature data were collected by thermographic measurement. As a result, lower-limb warming by a hot pack significantly improved the quality of sleep in the subjects. During warming, the surface temperature of the hands and face rose by approximately 0.5–1.5°C. This study showed that lower-limb warming with a hot pack reduced sleep latency and wake episodes after sleep onset; thus, improving the quality of sleep in elderly people living in a nursing home.

Keywords: Equipment and supplies; Skin temperature; Sleep wake disorders; Sleep; Lower extremity; Aged.

Corresponding author: Chika Oshima-Saeki. Department of Nursing, Nagoya University Graduate School of Medicine.

E-mail: chika@met.nagoya-u.ac.jp

Received: September 30, 2016;

Accepted: January 13, 2017.

INTRODUCTION

Sleep is a vital human function, but sleep difficulty is a common complaint in the elderly.

The overall prevalence of insomnia ranges from 14.0% to 42.2% in the general elderly population^{1,2}. They may have trouble falling asleep, frequent or prolonged nocturnal awakenings, or early morning awakenings with an inability to return to sleep³⁻⁵. These sleep disorders are often associated with an increased risk of accidents, falls, chronic fatigue, and impaired functioning, and also result in a slow deterioration of the individual's quality of life.

On the other hand, the suprachiasmatic nucleus, located in the hypothalamus, is the circadian pacemaker that regulates endocrine, body temperature, rest-wake cycles, and behavioral rhythms^{6,7}.

Body temperature and sleep-wake rhythms are highly correlated with the circadian rhythm^{8,9}. Based on evidences of relationships among body temperature, thermoregulation, and sleep, Kräuchi & Wirz-Justice¹⁰ suggested that heat loss from the core to the periphery, characterized by an abrupt decrease in proximal skin (infraclavicular, thigh, stomach, and forehead) and an increase in distal skin (hand and feet) temperatures, could predict initiation of sleep.

Therefore, an elevation in skin temperature and a fall in core temperature are both important for sleep. Age-related decline in thermoregulatory functions caused by decreased basal metabolism, decreased heat production with the loss of muscle mass^{11,12}, and decreased conservation of heat with decreased vasoconstrictor potency are changes known to occur with age. Body temperature in the elderly is significantly correlated with external temperature due to age-related atrophy of subcutaneous adipose tissue. Thermoesthesia in the elderly is less sensitive than that in young people¹³. Therefore, most elderly people have difficulty coping with cold conditions and hence suffer from sleep disturbance.

A hot foot bath before bed improves blood circulation, refreshes the whole body, and may be useful for promoting sleep. However, it is difficult for some elderly people with various disabilities to take hot foot baths before bed every night in a nursing home. We therefore developed hot-pack boots to warm the lower limbs instead of using hot foot baths¹⁴. Our previous studies have reported the effects of hot-pack boots on the core body temperature and blood flow in healthy young volunteers¹⁴, and on the body temperature of elderly people living in a nursing home¹⁵.

The objective of this study is to examine whether the warming of lower limbs by hot packs can improve the sleep of elderly people living in a nursing home.

MATERIALS AND METHODS

This is a prospective cohort study, without controls, involving 7 elderly subjects (all women) from a nursing home. This study was approved by the Ethical Review Board

at Ishikawa Prefectural Nursing University. We confirmed that there was no risk for low-temperature burns in this experiment. The purposes and methods of this study were fully explained to the subjects and their families in oral as well as written form, and signed consent was obtained from each subject prior to participation in this experiment.

Preparation of the hot pack

The hot pack was made as described in our previous study¹⁴. The core component of the hot pack was composed of a dense polymer and could be readily heated in a microwave oven. The hot pack was prepared as follows: 10 g of superabsorbent polymer (SUN FRESH ST-500D, San-Dia Polymers, Ltd.) was added to 2000 mL of water, and the resulting soft gel material was placed in a Ziploc bag. It weighed 200 g and measured 20 × 18 cm. The hot pack was heated in a microwave oven for 2 min to 42°C, and swathed in a cotton towel (34 × 85 cm). One hot pack was placed under the plantar surface of each foot and the other on the anterior surface of each leg (Figure 1). These hot packs maintained a constant temperature of 36°C–40°C for 40 min and didn't soar above 42°C. So the hot-pack has no risk of low temperature burn for adult and elderly people^{14,15}.

Subjects

We recruited 7 elderly subjects (all women) from the same nursing home to avoid differences in life patterns. The subjects were between 74 and 93 years old (mean age 87 ± 8.53). They did not have any severe behavioral problems, contractures, venous disease, peripheral neuropathy and communication disorders. Also, they did not use sleeping pills and 6 subjects had some degree of dementia.

Experimental room

The experiments were conducted in the day room or the private rooms of the nursing home, with an ambient temperature of 25°C–28°C and humidity of 40%–50%. The experiments were performed between May 5th and July 7th.

Methods

Procedures

Subjects received a lower-limb warming treatment for 40 min by hot packs every night over an 8 week period (Table 1). The investigation period (8 weeks) was based on a previous study, which demonstrated that tub bathing before bed for 8 weeks changed the circadian phase in the elderly¹⁶. In the first week (Table 1), the subjects were required to wear an activity monitor (Actigraph, AMI Inc., Ardsley, NY, USA) to estimate their sleep-awake status. During the second to ninth weeks, the subjects received a lower-limb warming treatment by hot packs heated to 42°C for 40 min every night. In the ninth week, the subjects were again required to wear an activity monitor to estimate their sleep-awake status.



Figure 1. The Procedure for taking hot packs. 1) Wrap a hot pack heated to 42°C by a cotton towel. 2)-4) Place hot packs over subjects's plantars and shins.

Table 1. Procedure for investigation.

	Mon	Tue	Wed	Thu	Fri	Sat	Sun
1 st week			← Wearing Activity monitor & Gross observation →				
2 nd week			← Using hot packs before bed for 40 min →				
3 rd week			← Using hot packs before bed for 40 min →				
4 th week			← Using hot packs before bed for 40 min →				
5 th week			← Using hot packs before bed for 40 min →				
6 th week			← Using hot packs before bed for 40 min →				
7 th week			← Using hot packs before bed for 40 min →				
8 th week			← Using hot packs before bed for 40 min →				
9 th week			← Wearing Activity monitor & Gross observation →				
			← Using hot packs before bed for 40 min →				

Measurement of sleep–wake status

Activity monitor (Actigraph, AMI Inc., Ardsley, NY, USA) was used to obtain objective sleep assessment when subjects were in nursing home. This device is piezo-electric accelerometers about the size of watch and is worn on the wrist. The Activity monitor was set to record activity counts in 30-s epochs. The Activity monitor counts represent both the occurrence and magnitude of arm movements. Movement data were sampled at rate of 32hz.

Data were analyzed using Action W software (Actigraph, AMI Inc.), automatic sleep scoring was performed using algorithms previously validated¹⁷. In evaluating quality of sleep, the following sleep parameters were estimated by Action W software (Actigraph, AMI Inc.): Sleep latency (SL), Total sleep time (TST), Duration of long-sleep episode (LGSP), Wake episode after sleep onset (WEP), Sleep efficiency (SE), Diurnal Activity Mean (DA mean) and sleep–wake status was estimated by Cole's algorithm¹⁸.

Statistical analysis

We used SPSS 13.0 for Windows for statistical analysis. The parameters of sleep were compared between the first and the ninth weeks by Wilcoxon signed-rank test. Differences of $p < 0.05$ were considered significant for all statistical analyses.

RESULTS

Sleep latency (SL): SL means the length of time it takes from lying down until sleep onset. The median SL in the first weeks was 47 minutes and the median SL in the ninth week was 11.25 minutes. There was a significant decrease in SL from the first to the ninth weeks ($p=0.043$).

Total sleep time (TST): TST means the amount of actually sleep time during the night. The median TST in the first week was 409.75 minutes and in the ninth week was 392.75 minutes, but the difference was not significant.

Duration of long-sleep episode (LGSP): LGSP means the amount of the time of the longest sleep period during the night. The median LGSP in the first week was 99.6 min and in the ninth week was 105.5 min. LGSP tended to increase over the study duration ($p=0.063$).

Wake episode after sleep onset (WEP): WEP means the number of Sleep Disruption during the night. The median WEP in the first week was 10.67 and in the ninth week was 9. There was a significant decrease in WEP from the first to the ninth weeks ($p=0.018$).

Sleep efficiency (SE): SE means the ratio of the total amount of time spent asleep to the total amount of time spent lying in a bed per night. The median SE in the first week was 77.37% and in the ninth week was 80.95%. There was no significant difference between the first and the ninth weeks.

Diurnal Activity Mean (DA mean): DA mean means the mean activity score during the day. Median DA mean in the first week was 156.43 and in the ninth week was 161.78. There was no significant difference between the first and the ninth weeks (Table 2).

DISCUSSION

We investigated whether warming of the lower limbs with hot packs improved the quality of sleep in elderly subjects living in a nursing home. Some studies

have reported that elderly people showed an increased SL and WEP and a decreased SE¹⁹. These age-related changes in sleep parameters occur from inhibition of heat dissipation, which is caused by the circadian rhythm disorder, decreased parasympathetic function, peripheral circulatory disturbance, and thickening of capillary walls. In addition, decreased response to entraining agents caused by diminished vision, deterioration in hearing, and isolation from society may also cause age-related changes in sleep parameters²⁰.

In this study, lower-limb warming using hot packs for 8 weeks significantly improved the subjects' quality of sleep. Wake time after sleep onset decreased, sleep latency decreased and LGSP tended to be prolonged (Table 2). It is conceivable that the core body temperatures reached a certain point by hot-pack application and then dilation of peripheral vessels was caused by a thermoregulatory function to prevent further elevation of the core temperature¹⁵. A slight decrease in the core temperature then may have promoted sleep.

Lower-limb warming using hot packs for 8 weeks suggested an optimum duration for promotion of sleep. Takayama²¹ and Liao²² suggested that a hot foot bath before bedtime over the 2-day study period could not promote sleep. Also, Deguchi et al.¹⁶ suggested that bathing before bedtime over a 12-week period could change the sleep–wake cycle in elderly people. These reports are consistent with our study. Hence, as indicated by these studies and ours it may be important to use a longer period or continual intervention for promotion of sleep in elderly people using lower-limb warming. In this study, all patients liked the hot packs and they had no complaints. The hot-pack warming method is an easy-to-use approach and is therefore useful for the promotion and improvement of sleep in elderly people.

CONCLUSIONS

In conclusion, the lower-limb warming using hot packs for 8 weeks significantly reduced sleep latency and wake episodes after sleep onset in elderly people living in a nursing home.

It is conceivable that the hot-pack warming method may be useful for inducing heat dissipation, which is caused by increased core body temperature. This study suggests that

Table 2. Parameters of sleep in 1st week and 9th week. n=7

	1 st week		9 th week		p value
	median	(mean±SD)	median	mean±SD	
Sleep latency(min)	47.00	(37.05±25.02)	11.25	(18.21±16.56)	0.043*
Total sleep Time after sleep onset(min)	409.75	(397.55±79.94)	392.75	(411.76±104.21)	0.612
Duration of long Sleep Episode(min)	99.60	(126.61±60.99)	105.50	(162.15±100.16)	0.063
Wake Episode after sleep onset (time)	10.67	(13.38±5.51)	9.00	(11±4.68)	0.018*
Sleep Efficiency(%)	77.37	(73.27±11.97)	80.95	(76.12±13.73)	0.091
Diurnal Activity Mean(time/min)	156.43	(156.10±39.53)	161.78	(150.75±32.10)	0.735

* $p < 0.05$: significant differences between 1st week and 9th week.

the hot-pack warming method is useful for the promotion and improvement of sleep in the elderly.

ACKNOWLEDGEMENTS

This study was supported by Japan Society for the Promotion of Science, Grant-in-Aid for Young Scientists (B) 18791641.

REFERENCES

1. Chiu HF, Leung T, Lam LC, Wing YK, Chung DW, Li SW, et al. Sleep problems in Chinese elderly in Hong Kong. *Sleep*. 1999;22(6):717-26.
2. Foley DJ, Monjan AA, Brown SL, Simonsick EM, Wallace RB, Blazer DG. Sleep complaints among elderly persons: an epidemiologic study of three communities. *Sleep*. 1995;18(6):425-32.
3. Ancoli-Israel S. Sleep problems in older adults: putting myths to bed. *Geriatrics*. 1997;52(1):20-30.
4. Ancoli-Israel S, Roth T. Characteristics of insomnia in the United States: results of the 1991 National Sleep Foundation Survey. I. *Sleep*. 1999;22 Suppl 2:S347-53.
5. Floyd JA, Medler SM, Ager JW, Janisse JJ. Age-related changes in initiation and maintenance of sleep: a meta-analysis. *Res Nurs Health*. 2000;23(2):106-17.
6. Dijk DJ, Duffy JF, Czeisler CA. Contribution of circadian physiology and sleep homeostasis to age-related changes in human sleep. *Chronobiol Int*. 2000;17(3):285-311.
7. Van Someren EJ. More than a marker: interaction between the circadian regulation of temperature and sleep, age-related changes, and treatment possibilities. *Chronobiol Int*. 2000;17(3):313-54.
8. Czeisler CA, Duffy JF, Shanahan TL, Brown EN, Mitchell JF, Rimmer DW, et al. Stability, precision, and near-24-hour period of the human circadian pacemaker. *Science*. 1999;284(5423):2177-81.
9. Hofman MA. The human circadian clock and aging. *Chronobiol Int*. 2000;17(3):245-59.
10. Kräuchi K, Wirz-Justice A. Circadian clues to sleep onset mechanisms. *Neuropsychopharmacology*. 2001;25(5 Suppl):S92-6.
11. Poehlman ET, Arciero PJ, Goran MI. Endurance exercise in aging humans: Effects on energy metabolism. *Exerc Sports Sci Rev*. 1994;22(1):251-84.
12. Kenney WL, Munce TA. Invited review: aging and human temperature regulation. *J Appl Physiol* (1985). 2003;95(6):2598-603.
13. Uchida Y, Tamura T. Regional difference of thermal sensitivity on the skin surface of elderly. *J Home Econ Jpn*. 2007;58(9):579-84.
14. Fujimoto E, Sasaki R, Arita H, Ohshima C. The hot-pack warming on the deep body temperature -for the development of a nursing care instrument to induce sleep. *Aino J*. 2008;7:13-9.
15. Ohshima C, Yoshida N, Arita H, Fujimoto E. The effects of hot-pack warming on skin temperature of the elderly. *Aino J*. 2009;8:25-33.
16. Deguchi A, Szumura E, Nakamura H, Kawamura N, Kawamura K. Night Spa Bathing for Patients with Senile Dementia. *J Jpn Soc Balneol Climatol Phys Med*. 2000-2001;64(2):71-5.
17. Jean-Louis G, Kripke DF, Cole RJ, Assmus JD, Langer RD. Sleep detection with an accelerometer actigraph: comparisons with polysomnography. *Physiol Behav*. 2001;72(1-2):21-8.
18. Cole RJ, Kripke DF, Gruen W, Mullaney DJ, Gillin JC. Automatic sleep/wake identification from wrist activity. *Sleep*. 1992;15(5):461-9.
19. Nakazawa Y, Nonaka K, Nishida N, Hayashida N, Miyahara Y, Kotorii T, et al. Comparison of body temperature rhythms between healthy elderly and healthy young adults. *Jpn J Psychiatry Neurol*. 1991;45(1):37-43.
20. Mishima Y, Hozumi S, Shimizu T, Hishikawa Y, Mishima K. Passive body heating ameliorates sleep disturbances in patients with vascular dementia without circadian phase-shifting. *Am J Geriatr Psychiatry*. 2005;13(5):369-76.
21. Takayama N, Okazaki S, Nakayama E. The study on the influence of foot care before bed on the sleep in the elderly people living in welfare facilities. *Jpn J Nurs Sci*. 2007;6(1):48-53.
22. Liao WC, Chiu MJ, Landis CA. A warm footbath before bedtime and sleep in older Taiwanese with sleep disturbance. *Res Nurs Health*. 2008;31(5):514-28.