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Original

The effect of hot-pack warming on the skin temperature of the elderly

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Abstract

A hot-pack made of a dense polymer and warmed in a microwave oven can be used as a warming instrument. This study was performed to examine the effects of a hot-pack, which was used to warm the lower limbs, on the skin surface temperature of elderly people living in a nursing home.

The results demonstrated that hot-pack warming is useful to increase the skin surface temperature of elderly people and to maintain a hyperthermic effect. This method of hot-pack warming can also be used as thermal therapy in elderly people living in nursing homes.

Key words: hot-pack, warming, skin surface temperature, thermography

Introduction

Age-related decline in thermoregulatory functions caused by decreased basal metabolism, decreased heat production with the loss of muscle mass (Poehlman, 1994; Kenney & Munce, 2003), and decreased conservation of heat with decreased vasoconstrictor potency (Harada et al., 2005) is known. Body temperature in the elderly is significantly correlated with external temperature due to age-related atrophy of subcutaneous adipose tissue (Harada et al., 2005). Thermoesthesia in the elderly is more insensitive than that in young people (Uchida & Tamura, 2007). Therefore, most elderly people cannot cope in cold conditions and are exposed to cold conditions without being aware of it.

For the abatement of such peripheral coldness, footbaths are useful as nursing care. Previous nursing studies have reported that hot footbaths improve peripheral circulation. However, considering the large number of elderly people living in nursing homes, it is difficult to give hot footbaths to all elderly people, since it is a labor intensive task. We therefore developed hot-pack boots to warm the lower limbs instead of using hot footbaths (Fujimoto et al. 2008). Our previous studies have reported the effects of hot-pack boots on the core body temperature and blood flow in healthy young volunteers (Fujimoto et al. 2008). However, the effects in elderly people have not been reported. This study examined whether warming of the lower limbs with a hot-pack affects the body temperature of elderly people living in a nursing home.

Materials and Methods

1. Preparation of the hot-pack

The hot-pack was made as our previous manuscript (Fujimoto et al. 2008). The core component of the hot-pack is composed of a dense polymer, and the hot-pack can be readily heated in a microwave oven. The

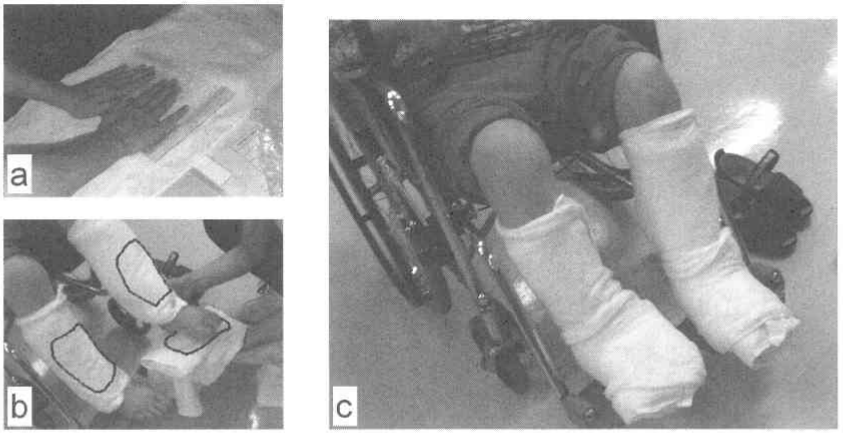

Fig. 1 Warming with hot-packs and their positions
a) Hot-pack is swathed in a cotton towl.
b) Hot-packs under the plantar surface of foot and on anterior surface of leg
c) Each lower limb is warming with two hot-packs.

hot-pack was prepared as follows: 10 g of superabsorbent polymer (SUN FRESH ST-500 D, 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 2min by 42℃, and swathed in a cotton towel (34×85 cm).

One hot-pack was placed under the plantar surface of each foot and the other one on the anterior surface of each leg (Fig. 1.). These hot-packs maintained a constant temperature of 36℃−40℃ for 40 min.

2. Subjects

We recruited 6 women from the same nursing home to avoid differences in life patterns. Subject ages ranged between 74 and 93 years old. They did not have severe abnormal behavior or communication disorders. They did not use to using sleeping pills and their activities corresponded to the daily living scale for demented of I to IIIb.

3. Experimental room

The experiments were conducted in the day room of the nursing home, with a temperature of 25℃−28℃ and humidity of 40%−50%.

4. Study periods

The experiments were performed between August 5th and 7th, 2008.

5. Methods

(1) Procedures

We started all tests at 2 p. m. to control the effects of circadian rhythm. On arrival in the day room, subjects were required to sit in a chair for 10 min (rest phase). Hot-packs heated to 42℃ were applied to the subjects and they were asked to remain seated in the chair for 40 min (warming phase). Then, the hot-packs were removed and the subjects remained seated in a chair for 20 min (post-warming phase).

(2) Measurement of skin surface temperatures

The skin surface temperatures of the face, forehead, back of the hands, and lower limbs were measured by dermal thermography. The thermographic data were collected at 5-min intervals using Handy Thermo (TV-200EX; AVIO Inc.). Thermographic data of lower limbs were not collected during warming, since the lower limbs were swathed in a cotton towel as shown Fig. 1c. Data were analyzed by software (Avio Thermography Studio 2007; AVIO Inc,).

6. Analysis

The average face, forehead, back of the hands, and lower limb temperatures measured for 10 min during the rest phase were used as baseline temperatures for each subject. Differences in temperatures from the baseline were calculated for 60 min (40 min during the warming phase and 20 min during the post-warming phase) in each subject. Then, the average differences were calculated for

each subject.

7. Ethical consideration

It was 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 before participating in this experiment.

Results

(1) Changes in the skin surface temperature of the face

Five of six subjects showed an increase in the skin surface temperature of the face (Fig. 2). They showed a slight decrease in temperatures at the post-warming phase. Twenty min after the end of the warming phase, the subjects continued to show a temperature increase 0.6℃−1.0℃ from their baseline temperatures; the average temperature was elevated by 0.6℃ from the baseline ($p=0.066$).

(2) Changes in the skin surface temperature of the forehead

Five of six subjects showed an increase in the skin surface temperature of the forehead (Fig. 3). These subjects continued to show an increase of 0.6℃−1.3℃ from their baseline temperatures 20 min following the end of the warming phase. The average temperature showed a maximal increase of 0.8℃ from the

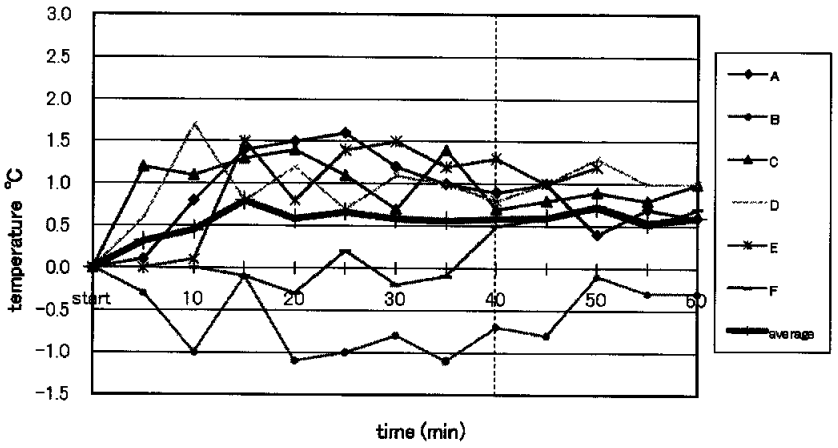

Fig. 2 Changes in the skin surface temperature of the face
Mark of "start": the start point of warming
Vertical broken line: the end point of warming

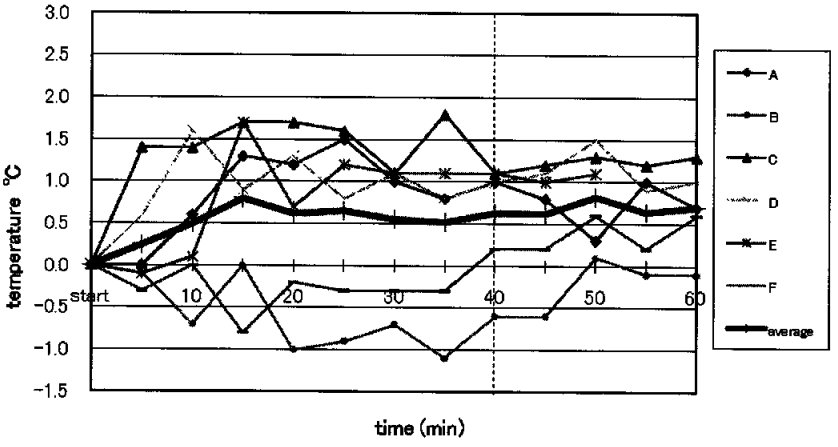

Fig. 3 Changes in the skin surface temperature of the forehead
Mark of "start": the start point of warming
Vertical broken line: the end point of warming

baseline at 15 min and 50 min following the start of warming. In particular, the average temperature at 50 min following the start of warming showed a significant difference ($p=0.017$). In 1 of the 5 subjects who showed an increase, the temperature was lower than that at baseline in the warming phase, but higher than that at baseline at the end of the post-warming phase.

(3) Changes in the skin surface temperature of the back of the left and right hands

Four subjects (other 2 subjects were impossible measure) showed an increase in the skin surface temperature of the back of the left hand (Fig. 4). Each subjects' temperatures increased gradually and reached a maximum level at the end of the warming phase (35−40 min). The average temperature showed a maximal increase of 1.7℃ from baseline at 35 min following the start of warming ($p=0.008$). One subject continued to show an elevation of 2.6℃ from the baseline at the end of the post-warming phase.

Four of five subjects showed an increase in the skin surface temperature of the back of the right hand (Fig. 5) (one subject was impossible measure). Three subjects showed the maximum temperature at the end of the warming phase (35−40 min).

The average temperature increased by a maximum value of 0.9℃ from baseline at 40 min after the start of warming ($p=0.066$). One subject continued to show an elevation from the baseline at the end of the post-warming phase, but two other subjects showed gradual decreasing temperature at the end of the warming phase.

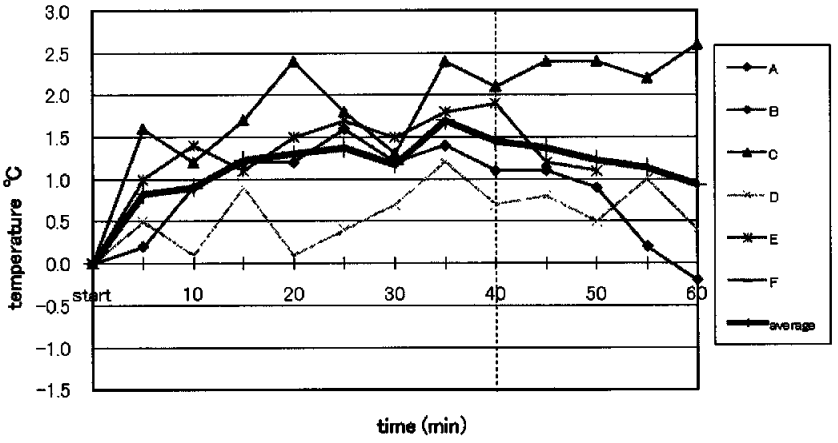

Fig. 4 Changes in the skin surface temperature of the back of the left hand
Mark of "start": the start point of warming
Vertical broken line: the end point of warming

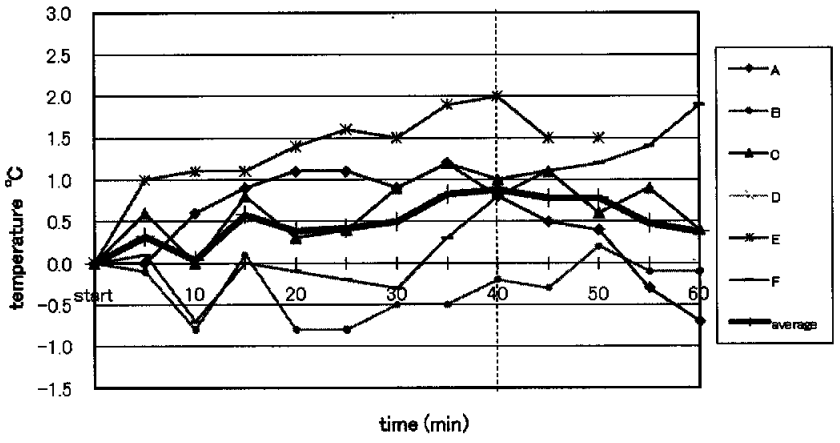

Fig. 5 Changes in the skin surface temperature of the back of the right hand
Mark of "start": the start point of warming
Vertical broken line: the end point of warming

(4) Changes in the skin surface temperature of the back of left and right lower limbs

All subjects showed an increase in the skin surface temperature of the lower limbs at the post-warming phase (Figs. 6 and 7). The average temperature gradually decreased, but was higher than the baseline value at the end of the post-warming phase.

(5) Individual Data

All subjects were divided into 2 groups. Group 1 showed a characteristic increase in temperature (Subjects A. C. D. E), Group 2 did not show an increase in temperature (Subject B).

1) Subject A. C. D. E

Hydropoiesis was not observed during any of the experimental phases. Four subjects (A, C, D, E) showed an increase in the skin surface temperature of the back of their hands just after the increase in skin surface temperature of the face (Figs. 8–11); 1 did not (subject B).

Subject A

This subject showed an increase in the skin surface temperature of the forehead and backs of the hands 5–15 min following the start of warming (Fig. 8).

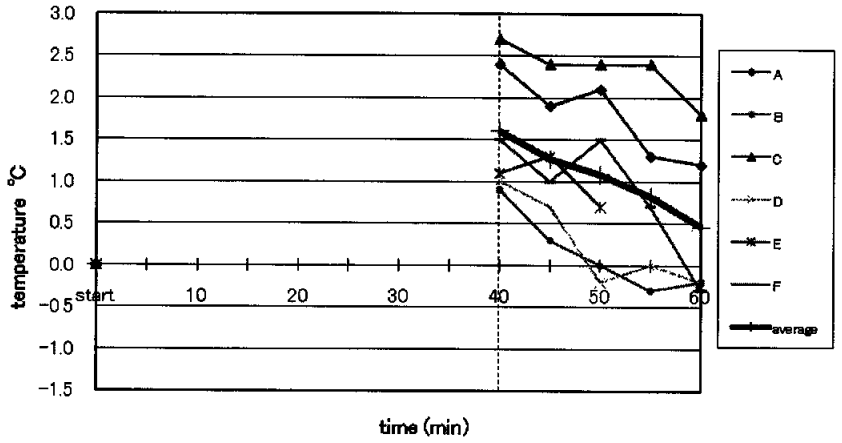

Fig. 6 Changes in the skin surface temperature of the left lower limb
Data are not collected during warming, since the lower limbs are swathed in a cotton towel.
Mark of "start": the start point of warming
Vertical broken line: the end point of warming

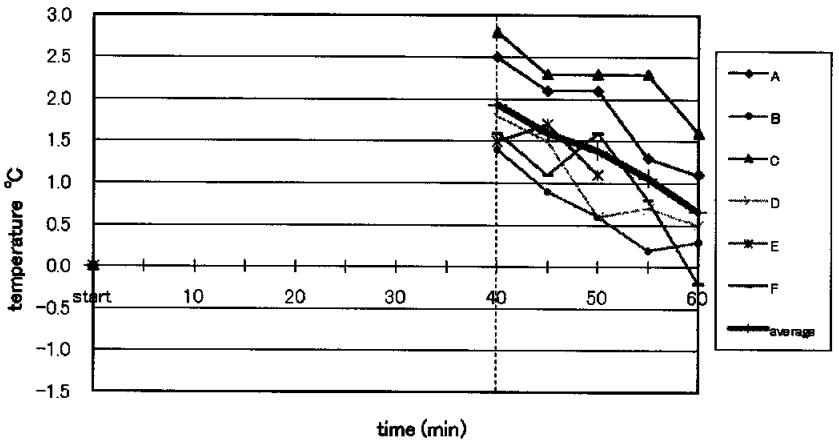

Fig. 7 Changes in the skin surface temperature of the right lower limb
Data are not collected during warming, since the lower limbs are swathed in a cotton towel.
Mark of "start": the start point of warming
Vertical broken line: the end point of warming

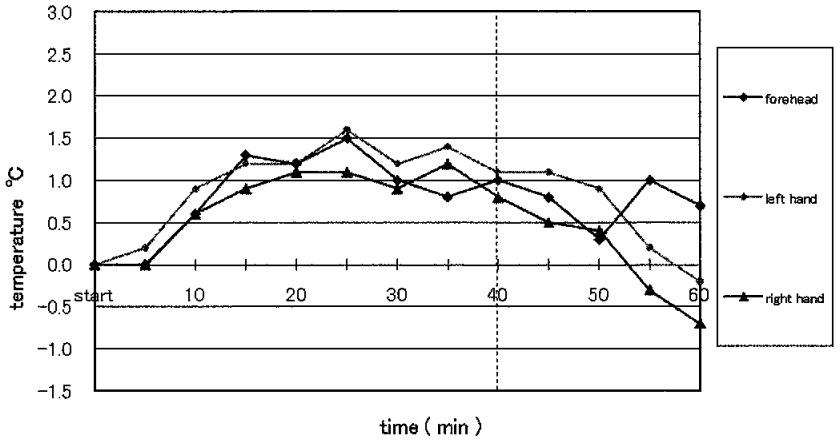

Fig. 8 Changes in the skin surface temperature of subject A
Mark of "start": the start point of warming
Vertical broken line: the end point of warming

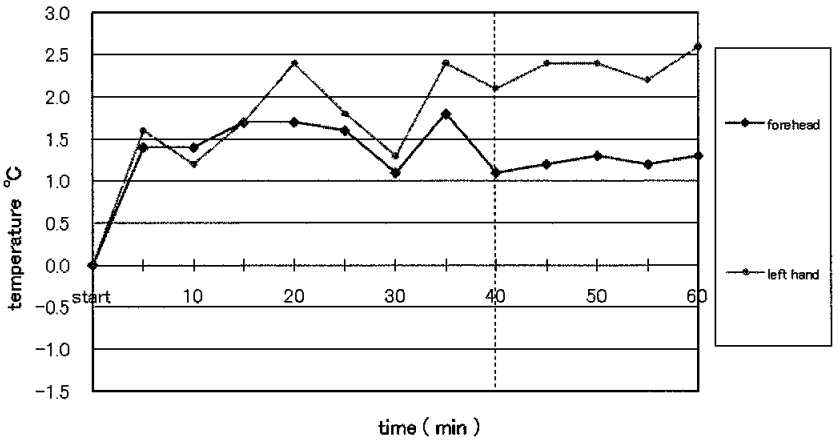

Fig. 9 Changes in the skin surface temperature of subject C
Mark of "start": the start point of warming
Vertical broken line: the end point of warming

Subject C

This subject showed a rapid increase in the skin surface temperature of the forehead and back of the left hand 35 min following the start of warming and a decrease in temperature at 40 min (Fig. 9). A constant temperature was recorded during the post-warming phase.

Subject D

Ten, 20, and 50 min following the start of warming, subject D showed a remarkable increase in the skin surface temperature of the forehead but a decrease in the skin surface temperature of the back of the hands. At 15 and 35 min following the start of warming, subject D showed a remarkable increase in the skin surface temperature of the back of the hands but a decrease in the skin surface temperature of the forehead (Fig. 10).

Subject E

Subject E showed a remarkable increase in the skin surface temperature of the forehead 15 min following the start of warming and a constant temperature after 25 min (Fig. 11). Fifteen min following the start of warming, subject E showed an increase in the skin surface temperature of the forehead but a decrease in skin surface temperature of the backs of the hands.

2) Subject B

Subject B showed a higher temperature of the face, forehead, and back of the left hand than other subjects during the rest phase. Temperatures of the face, forehead, and back

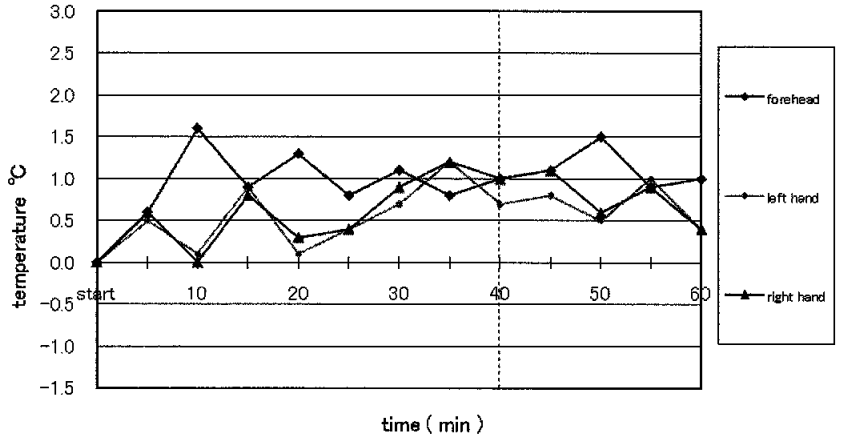

Fig. 10 Changes in the skin surface temperature of subject D
Mark of "start": the start point of warming
Vertical broken line: the end point of warming

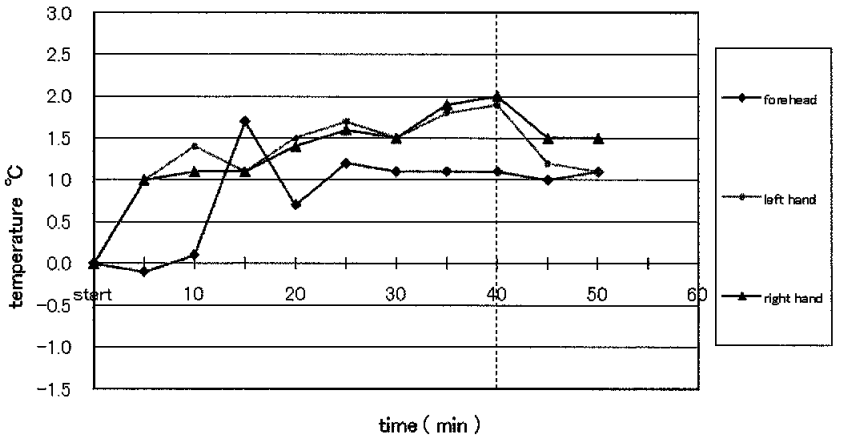

Fig. 11 Changes in the skin surface temperature of subject E
Mark of "start": the start point of warming
Vertical broken line: the end point of warming

of the left hand were 35.7℃, 35.7℃, and 36.1℃, respectively (Fig. 12).

In the skin surface temperatures of face, forehead, and back of the left hand, subject B 5–45 min following the start of warming showed lower values than those during the rest phase. Fifty min following the start, the temperatures reached baseline but showed lower values than the rest phase at the end of the post-warming phase (Fig. 13).

Since subject B had been diagnosed with dementia, subjective symptoms of sudation could not be assessed. Objective symptom of sudation was not detected at least in the face, hand and lower limbs.

Discussion

We investigated whether warming of the lower limbs with hot-packs increases the body temperature of elderly people. In this study, 4 subjects showed an increase in the skin surface temperature of the forehead. Temperature of the forehead is generally recognized to reflect the core temperature (Harioka et al., 1993). Although It was not clearly documented whether the increase in forehead temperature was caused by increased blood flow and heat gradient, our hot-pack seems sure to be useful for increasing core temperature.

Four subjects showed increased skin surface temperatures of the back of their hands just after the increase in skin surface temperature of the forehead. It is conceivable that the increase in temperature in the hands was caused by activity of sympathetic nervous system. When the core temperature increases,

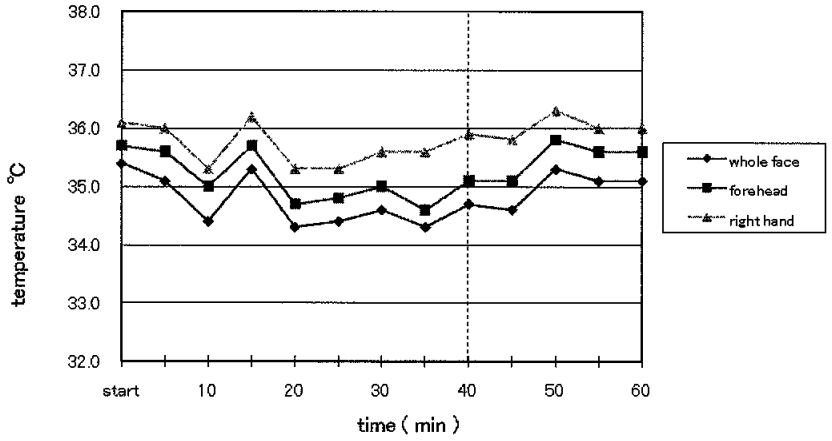

Fig. 12 Skin surface temperature of subject B
Mark of "start": the start point of warming
Vertical broken line: the end point of warming

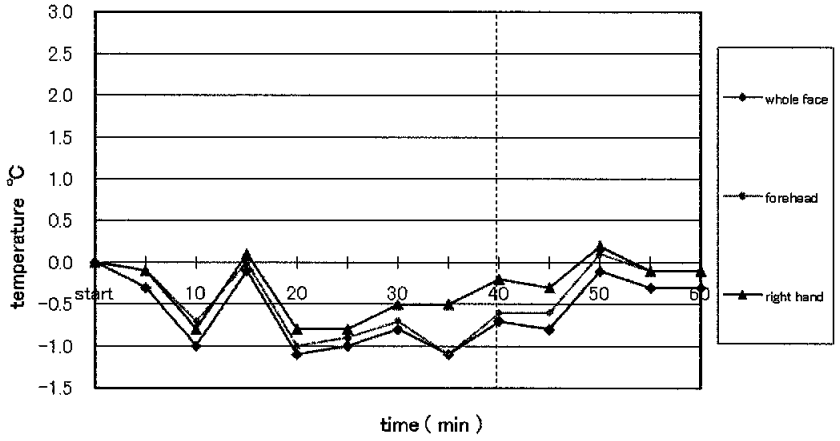

Fig 13 Changes in the skin surface temperature of subject B
Mark of "start": the start point of warming
Vertical broken line: the end point of warming

it is regulated by sympathetic inhibition to maintain a constant temperature. It is conceivable that the increase in forehead temperature was a measure of the core temperature increase caused by hot-pack application, then, the temperature increase in the back of the hands was caused by dilation of peripheral vessels to prevent an excess increase in core temperature.

Subject B showed higher temperatures of the face, forehead, and back of the left hand than other subjects during the rest phase. However, there were no temperature increases on the face, forehead, or back of the left hand. It is conceivable that Subject B's core temperature had reached a set-point during the rest phase and the dilation of peripheral vessels was caused by a thermoregulatory function to prevent further elevation of the core temperature. Our findings support so-called the set-point theory (Seeley et. al. 2007). However, we did not measure blood flow or heat gradient to confirm this hypothesis. Further detailed research to determine hidropoiesis in the axillary, abdominal, and posterior regions covered by clothes is required.

All subjects showed increased skin surface temperature of the lower limbs during the post-warming phase. At the end of the post-warming phase, the average temperatures were higher than those at baseline (Figs. 6 and 7). The average temperatures of the face, forehead, and back of the hands showed higher values than those at baseline for 10 min following the end of warming. Evaporation leads to a loss of heat from the skin surface after a bath or hot footbath, but not after

hot-pack warming. It is conceivable that the vasoconstriction reflex was not induced by hot-pack warming; therefore, hot-pack warming could maintain increased blood flow after the end of hot-pack warming, unlike the use of hot baths or hot footbaths. Therefore, this hot-pack warming method is useful to maintain a hyperthermic effect in elderly people.

In conclusion

Hot-pack warming of the lower limbs induced heat dissipation, which is caused by increased core body temperature. It is conceivable that the hot-pack warming method may be useful to increase the skin temperature of elderly people demonstrating sensitivity to cold temperatures. This study suggests that the hot-pack warming method is useful to maintain a hyperthermic effect.

Elderly people with thermoregulatory dysfunction are sensitive to cold temperatures. Elderly people who live in nursing homes have a reduced amount of physical activity and reduced frequency of tub baths; therefore, they are more sensitive to cold temperatures.

We think that this method of hot-pack warming is applicable as a type of thermal therapy for elderly people living in nursing homes.

Acknowledgments

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References

1. 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, 7: 13–19, 2008
2. Harada T: Koureisha no Hifu no Tokuchou (characteristics of skin of elderly people). Geriatric Medicine 43: 1153–1157, 2005 (in Japanese)
3. Harioka T, Sone T, Monura K. et al: Relative accuracy and precision of two non-invasive thermometry system. Masui 42: 856–8 61,1993 (in Japanese)
4. Kenney W L, Munce T A: Invited Review: Aging and human temperature regulation. J Appl Physiol 95: 2598–2603, 2003
5. Poehlman E. Arciero P J, Goaron M I: Endurance exercise in aging humans: effects on energy metabolism: In Exercise and Sports Science Reviews 22(1), 251–279, 1994
6. Seeley R R. Stephens T D, Tate P: Chapter one, The human organism, Homeostasis. In: Seeley R R, eds. Essentials of Anatomy & Physiology. 6th 1–18, 2007
7. Uchida Y, Tamura T: Regional difference of thermal sensitivity on the skin surface of elderly. Nippon Kasei Gakkaishi 58: 579–584, 2007 (in Japanese)