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Preferred ambient temperature for old and young men in summer and winter

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Abstract. To investigate the effects of age on thermal sensitivity, preferred ambient temperature (T_{pref}) was compared between old (71–76 years) and young (21–30 years) groups, each consisting of six male subjects in summer and winter. The air temperature (T_a) was set at either 20° C or 40° C at commencement. The subject was directed to adjust the T_a for 45 min by manipulating a remote control switch to the level at which he felt most comfortable. In the older group, the T_{pref} was significantly lower in trials starting at 20° C than that starting at 40° C in summer. The fluctuation of T_{pref} (temperature difference between maximum and minimum T_a during the last 10 min) was significantly wider in the older group in both summer and winter. Repetition of the same experiment on each subject showed a poorer reproducibility of T_{pref} in the older group than in the younger group in summer. Tympanic and esophageal temperatures of the older group kept falling throughout the trial starting at 20° C in summer. These results suggest that thermal sensitivity is decreased with advancing age and that thermal perception in the elderly, especially to cold, is less sensitive in summer.

Key words: Preferred temperature – Aging – Thermal sensitivity – Seasonal difference

Introduction

Tolerance to heat and cold has generally been believed to decrease with advancing age; diminution in thermal perception is considered to be responsible in part for this decreased tolerance. Several studies have been reported concerning thermal sensitivity in the old. It has been shown that cutaneous cold spots are less densely distributed in elderly men (Murata and Iriki 1974) and that thermal discrimination in men is decreased with advancing age (Cowburn and Fox 1974; Dyck et al. 1974; Collins et al. 1981). In addition to the reduced thermoregulatory responses, reduced functions of thermal perception in the aged may blunt their thermoregulatory behavior to heat or cold stress, and thus facilitate onset of hyperthermia or hypothermia in daily life.

The present study was proposed to investigate the effects of aging on thermal sensitivity through the comparison of preferred ambient temperatures between the old and the young. Furthermore, experiments were carried out in summer and winter, to examine the seasonal differences in thermal perception.

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Methods

Subjects. Subjects were healthy male volunteers of two age groups, one consisting of six old men (group O) aged 71 to 76 years (average 73±2) and the other of six young men (group Y) aged 21 to 30 (average 24±4). None had a history of serious illness or were receiving any medications. All the subjects were intelligent and those in group O showed no signs of mental weakness. They had been well informed of the protocol and had given their consent.

Measurements. Air temperature (T_a) in the climatic chamber, esophageal temperature (T_{es}), tympanic temperature (T_{ty}), and skin temperatures at seven sites (forehead, chest, forearm, hand, thigh, calf, and foot) were measured with thermistors and recorded digitally at 1 min intervals using a minicomputer (Melcom 70/10 system, Mitsubishi). T_a was measured near the chest of the subject.

Data analysis. The mean skin temperature ($\bar{T}_s$) was calculated using the following equation:

$$\bar{T}_s = 0.07T_{forehead} + 0.35T_{chest} + 0.14T_{forearm} + 0.05T_{hand} + 0.19T_{thigh} + 0.13T_{calf} + 0.07T_{foot}.$$

Statistical analysis was carried out using Student's t-test.

Procedures. Experiments were carried out in summer (August and September) and winter (December and January). The experimental session was divided into four periods:

(1) An equilibration period. The subject wearing only short pants rested for 30 min in a sitting position in a pre-test chamber at 29° C, where thermistors were attached in place.

(2) A voluntary adjustment period (the first trial). The subject moved to a climatic chamber where the T_a had been set at 20° C

next to the pre-test chamber, and sat on a stool. After 5 min, adjustments to the T_a were made by dialling a remote control switch to a level at which he felt most comfortable. He was urged to keep adjusting the T_a for the next 45 min. Also, an alarm was rung every 2 min as a reminder to reconsider the comfortableness of the T_a. The air was made turbulent by the use of two electric fans in the chamber and the air velocity was maintained at 0.5 ± 0.2 m/s. The wet bulb temperature was clamped at 19.4° C. The subject was not informed of the T_a value which he had set. The T_a of the climate chamber was changed at a rate of up to 3.5° C/min upon resetting.

(3) A rest period. The subject returned to the pre-test chamber at 29° C and rested for 15 min.

(4) A voluntary adjustment period (the second trial). The subject reentered the climatic chamber, where the T_a had been reset at 40° C, and performed the same manipulation as in the first trial.

Each subject underwent two experiments at an interval of 1 to 7 days each in summer and in winter. In consideration of the circadian variation of the preferred temperature (Terai et al. 1985), all of the experiments were first planned to start at the same hour of the day in all the subjects; however, due to the difficulty in arranging schedules among subjects, experiments were started at 0900–1300 hours in all of the old subjects and three of the young men, and at 1600 hours in the rest of the young. All of the experiments on a single subject were started at the same hour of the day.

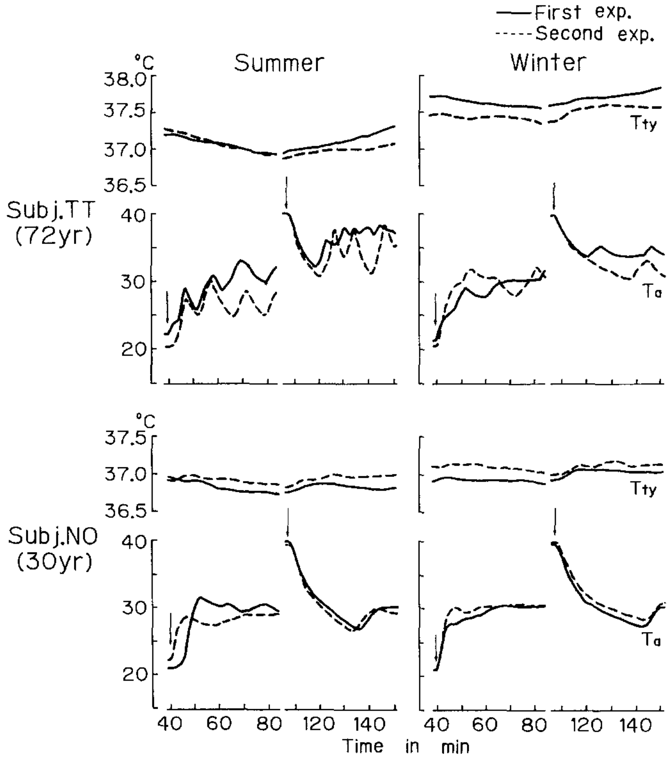

Fig. 1. Superimposed records of two experiments on a single subject in summer and winter showing changes in the tympanic temperature (T_{ty}) and air temperature (T_a). The *arrows* indicate commencement of the procedure

Results

The mean value of T_a during the last 10 min of the voluntary adjustment period was considered the preferred temperature (T_{pref}). Experimental records of T_{ty} and T_a for a subject of each group are shown in Fig. 1 and the statistical data of T_{pref} and $\bar{T}_s$ for all the subjects of each group in Fig. 2. In group Y, little difference was noted in T_{pref} between the first trial starting at 20° C and the second one starting at 40° C either in summer or in winter. This finding was also the case for group O in winter. However, the T_{pref} for group O was influenced by the preset T_a in summer: the T_{pref} of the first trial was lower than that of the second one in most cases, and also lower than that of the corresponding trial in winter in many cases. These differences were statistically significant ($P<0.01$, $P<0.05$, respectively). The mean value of $\bar{T}_s$ during the last 10 min showed a pattern similar to the T_{pref}.

Consistency of T_{pref} was investigated as the difference in T_{pref} between the first and second experiments for each trial. The temperature difference tended to be greater in group O than in group Y in summer, and was also greater in summer than in winter in group O; however, there were no significant differences as considerable individual variations occurred, especially in group O (Fig. 3). The temperature difference between the maximum and minimum values of T_a during the last 10 min in each trial was regarded as the fluctuation of T_{pref}. It was significantly greater in group O than in group Y in both summer and winter. No significant seasonal difference was noted in either group (Fig. 4).

The time course of mean values and standard errors of T_{ty} and T_{es} during each trial are shown for each group in Fig. 5. In the initial several minutes of the first trial

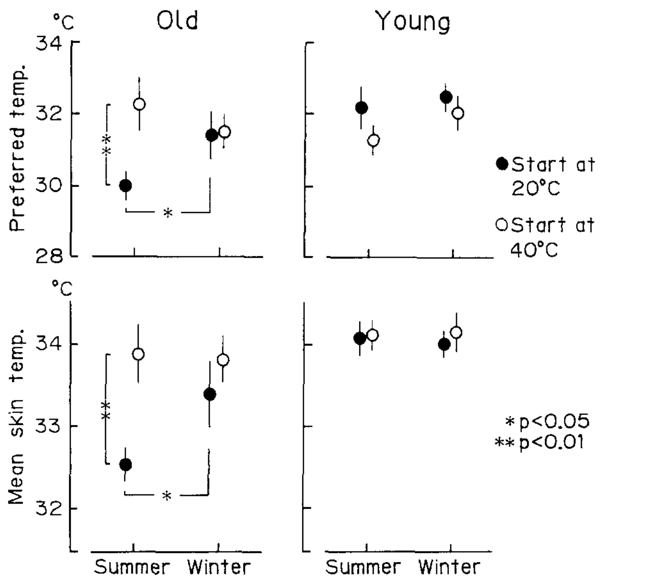

Fig. 2. Mean values of preferred temperature and mean skin temperature during the last 10 min of the procedure ($n=12$, mean ± SE)

starting at 20° C, the T_{ty} and T_{es} showed a transient rise in group Y in both summer and winter. The initial rise in T_{ty} was less than in T_{es}. An initial rise in T_{es} was also noted in group O in both summer and winter, but was lower than in group Y. T_{ty} showed no initial rise in group O. In group O, the values of T_{ty} and T_{es}

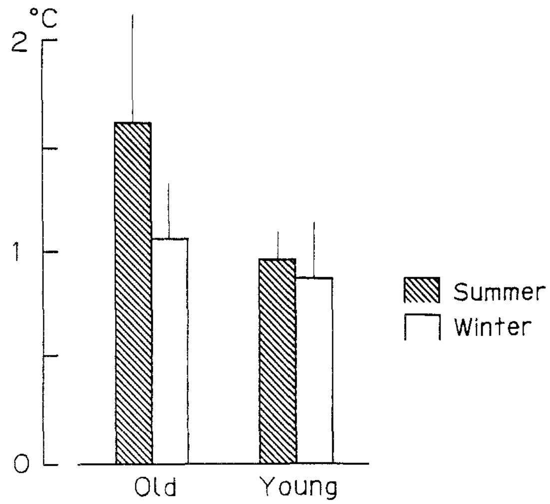

Fig. 3. Temperature difference in preferred temperature between the first and second experiments in each trial ($n = 12$, mean ± SE)

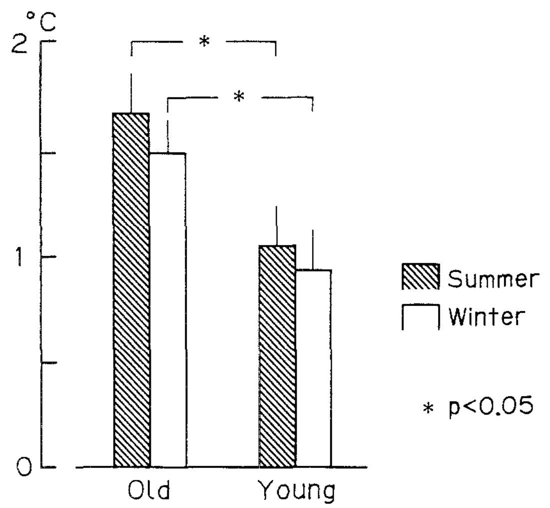

Fig. 4. Temperature difference between maximum and minimum air temperature in each trial during the last 10 min ($n = 24$, mean ± SE)

in summer tended to be lower than those in winter from the beginning of the first trial and kept decreasing during the procedure; seasonal differences became significant from about the middle of the operative period. The T_{ty} and T_{es} of the second trial were significantly lower in summer than in winter throughout the operative period in group O. T_{ty} and T_{es} for group Y showed little seasonal difference in either trial.

Discussion

An experiment such as this which is demanding of the subject's technique may be affected by his intelligence. The subjects were therefore subjected accordingly, especially for group O. All the subjects soon got the knack for manipulating the remote control switch and none of them were confused when handling it. It has been demonstrated that T_{pref} is affected by the time of day (Terai et al. 1985). Since the experiments could not be carried out in the same hours of the day for the two groups, the absolute values of T_{pref}, T_{ty}, T_{es}, and $\bar{T}_s$ could not be directly compared between groups O and Y. However, each subject underwent all of four experiments at specified hours of the day, so that comparisons of the data within each group were feasible.

Wider fluctuations of T_{pref} were observed in group O than in group Y in the present study. Similar observations have been made by Collins et al. (1981), and were ascribed to a decrease in the ability to discriminate temperature differences. There have been several studies indicating diminished thresholds of thermal discrimination with advancing age (Cowburn and Fox 1974; Dyck et al. 1974; Collins et al. 1981); this effect may be attributed in part to degeneration of thermoreceptors (Murata and Iriki 1974), and to diminution of the sensitivity of functioning nerve fibers due to a decrease in oxygen supply to cutaneous tissues in the old (Collins and Exton-Smith 1983). Furthermore, it is conceivable that central thermal sensitivity may be decreased in the aged, but no information is available concerning age-related changes in central sensitivity. On the other hand, Kenshalo (1977) found no significant differences in warm and cold thresholds between the young and the old. There appears to be a wide variation in thermal perception among elderly individuals.

It is considered that the reproducibility of T_{pref}, as suggested by the differences in T_{pref} between the first and second experiments for each trial, is an indication of stability and reliability of thermal sensitivity. Temperature differences tended to be greater in group O than in group Y in summer, although these were not significant. Another seasonal difference observed in group O was that T_{pref} was significantly lower in the first trial starting at 20° C than in the second trial starting at 40° C in summer, but not in winter, and that T_{pref} of the first trial was significantly lower in summer than in winter. These observations suggest that thermal perception, in particular perception of cold, is less sensitive in summer

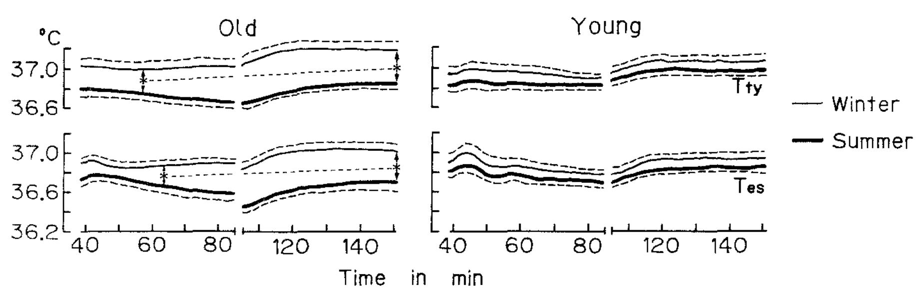

Fig. 5. Time courses of mean value and standard error (*dashed lines*) of the tympanic temperature and esophageal temperature ($n = 12$). * $P < 0.05$ (in the range shown by the *dotted lines*)

than in winter in the old. The finding that T_{ty} and T_{es} for group O tended to be lower in summer than in winter from the beginning of the first trial may be attributed partly to reduced thermal input from cold receptors to the central thermoregulatory mechanism. To our knowledge, this paper presents the first implication of seasonal difference in thermal perception of elderly men. Control of indoor climate, of course, is important for the old, but we should also take care that their air-conditioned environments should not be cooled too excessively in summer. In view of decreased thermal perception in the old, it may not be adequate to leave the control of their indoor environment to their own preferences. T_{pref} in the old is not always an optimum temperature, and in some cases, leads to lowering (Fig. 5) or raising of body temperature. Fox et al. (1973) noted that many elderly people who have a low oral temperature do not feel cold despite their living in a considerably cold environment.

In addition to decreased thermal perception, a decline in thermoregulatory responses to heat and cold such as vasomotor responses, shivering, and sweating in the elderly (Wagner et al. 1974; Ogawa 1988; Asaki 1989) may accelerate the change in their body temperature. A lower initial rise in T_{ty} and T_{es} was observed in group O than in group Y upon exposure to cold in the present study. Since such an initial rise in body temperature is believed to be caused mainly by a rapid decrease in skin blood flow due to vasoconstriction, those observations imply that vasoconstrictive response to cooling slows and/or declines with advancing age.

According to Fanger (1970) and Langkilde (1979), thermally comfortable temperature is identical for the old and the young. Fanger (1970) noted that the same temperature for thermal comfort between the old and the young was due to the same decrement of evaporative heat loss as that of metabolic rate with advancing age. On the other hand, Langkilde (1979) suggested that a somewhat higher optimum temperature for elderly men should be recommended because of less activity in their daily life. ASHRAE (1966) suggested that the optimum indoor temperatures should be about 0.5° C higher for people over 40 years. However, since there is a wide individual variation in age-related decrease in thermoregulatory function, an appropriate temperature for each individual should be taken into account in designing optimum environments for older people.

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