Effect of exercise training on body temperature in the elderly: a retrospective cohort study

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Abstract

Background

Although rise in body temperature in the elderly has clinical benefits such as activating immune system, little is known regarding the mediator related to the elevation of body temperature. This study evaluated the effect of exercise training on body temperature and clarified the relationship between body temperature and body composition in the elderly.

Methods

In this retrospective cohort study, a total of 91 elderly participants performed aerobic and anaerobic exercise training twice a week for 2-year. Non-contact infrared thermometer and bioelectrical impedance analysis were performed at baseline and at 2-year. The participants were divided into 2 groups by baseline body temperature of 36.3°C; lower body temperature group (n = 67) and normal body temperature group (n = 24).

Results

Body temperature rose significantly after exercise training (36.04 ± 0.01 °C to 36.30 ± 0.02 °C, $p < 0.0001$) in the lower body temperature group, whereas there was no significant difference (36.35 ± 0.02 °C to 36.36 ± 0.03 °C, $p = 0.39$) in the normal body temperature group. A positive correlation was observed between the amount of change in body temperature and baseline body temperature ($r = -0.68$, $p < 0.0001$). Increase in skeletal muscle mass was an independent variable related to the rise in body temperature by the multivariate logistic regression analysis (odds ratio: 4.77, 95% confidence interval: 1.29–17.70, $p = 0.02$).

Conclusions

Exercise training raised body temperature in the elderly, especially those with lower baseline body temperature.

Introduction

Body temperature is one of the major physiological parameter related to health condition, which differs by age and elderly has lower body temperature compared to young adults [1]. Decrease in body energy expenditure, skeletal muscle mass and physical activity in the elderly attenuate to lower body temperature [2–4], which contribute to inactivate immune function against infection and cancer [5–9]. Exercise training, including aerobic and anaerobic, is effective to increase body energy expenditure and skeletal muscle mass. Although exercise training contributes to raise body temperature, little is known about the

relationship between exercise training and body temperature. Accordingly, we investigated the effect of exercise training on body temperature and clarified the relationship between body temperature and body composition in the elderly.

Methods

Study population

This single center retrospective cohort study included 91 consecutive elderly participants (≥ 70 years old) who had exercise training twice a week for 2-year between December 2015 and December 2018. We obtained written informed consent from all participants. The study protocol was approved by the ethics committee of Tsurumi Ryokuchi Hospital. The investigation conformed with the principles outlined in the Declaration of Helsinki. Baseline clinical characteristics including age, sex, hypertension, diabetes mellitus, orthopedic disease and previous cerebral infarction were extracted from the medical record.

Evaluation Of Body Temperature And Body Composition

Body temperature was measured before exercise from participant's forehead using a non-contact infrared thermometer (Thermo Phrase MT-500, NISSEI, Gunma, Japan) after 15 minutes rest in a room maintained at 20 °C environmental temperature. Average body temperature for one month was evaluated to minimize individual body temperature variation at baseline and at 2-year. Participants were divided into 2 groups by baseline body temperature of 36.3 °C which is a standard body temperature in the elderly by previous systematic review [1]: lower body temperature group (< 36.3 °C) and normal body temperature group (≥ 36.3 °C). Body composition including body weight, metabolic rate, skeletal muscle mass and body fat mass were measured at baseline and at 2-year using bioelectrical impedance analysis (InBody 430, InBody Japan, Tokyo, Japan) [10].

Exercise Protocol

Exercise training consisted of aerobic and anaerobic exercise. After measuring body temperature, beginning with a warm-up stretch for 15 minutes, participants performed aerobic exercise; 10 minutes of cycling with an aero bike (AB158EXI, Konami Sports Life Co., Ltd, Kanagawa, Japan), and 10minutes of stair ascent and descent training (SP-100, SAKAI Medical Co., Ltd, Tokyo, Japan). Anaerobic exercise consisted of leg press, leg extension, seated rowing, hip adduction, pre-step and torso flexion using exercise machine (COP 902F-906F, COP-STEP, SAKAI Medical Co., Ltd, Tokyo, Japan) for 30 minutes. All the exercise procedures were assisted by physical therapists.

Statistical Analysis

Continuous variables are presented as means with standard deviations and categorical variables as number of total (percentages). Differences between the 2 groups were analyzed using the Student's t-test for continuous variables and the Chi-square test for categorical variables. Differences between baseline and 2-year data were conducted using the paired t-test. Correlation between 2 variables was determined by the linear regression analysis. Multivariate logistic regression analysis using 6 variables was performed. Categorical variables were subdivided as skeletal muscle mass; increase of > 0 kg or ≤ 0 kg, and metabolic rate; increase of > 0 kcal or ≤ 0 kcal. JMP 14.2.0 software (SAS Institute Inc., Cary, NC, USA) was used for all statistical analyses. A p-value < 0.05 was considered significant.

Results

Mean age of study participants was 81.0 years and mean body temperature was 36.1 ± 0.2 °C. Baseline clinical characteristics of lower body temperature group (n = 67) and normal body temperature group (n = 24) are shown in Table 1. Body mass index and body fat mass were significantly lower in lower body temperature group. Figure 1 shows the change in body temperature from baseline to 2-year. Lower body temperature group showed a significant rise in body temperature at 2-year (36.04 ± 0.11 °C to 36.30 ± 0.13 °C, $p < 0.0001$), whereas there was no significant difference in the normal body temperature group (36.35 ± 0.07 °C to 36.36 ± 0.13 °C, $p = 0.39$). Compared to normal body temperature group, lower body temperature group had significantly larger change of body temperature from baseline to 2-year (lower body temperature: 0.26 ± 0.12 °C vs. upper body temperature: 0.01 ± 0.12 °C, $p < 0.0001$, Fig. 2). The amount of changes in body temperature from baseline to 2-year had a strong correlation with baseline body temperature (Fig. 3). Lower body temperature group had significantly higher incidence of increase of skeletal muscle mass after exercise compared to normal body temperature group, whereas there was no significant difference in metabolic rate between the 2 groups (Fig. 4). When multivariate logistic regression analysis was performed, increase of skeletal muscle mass after exercise emerged as an independent variable related to the rise in body temperature (odds ratio: 4.77, 95% confidence interval: 1.29–17.70, $p = 0.02$, Table 2).

Table 1
Baseline clinical characteristics.

	Lower body temperature (n = 67)	Normal body temperature (n = 24)	p value
Age (years)	81.3 ± 4.5	80.5 ± 3.6	0.49
Male	24 (36)	8 (33)	0.83
Body temperature (°C)	36.0 ± 0.1	36.4 ± 0.1	< 0.0001
Comorbidity			
Hypertension	18 (27)	5 (21)	0.56
Diabetes mellitus	9 (13)	2 (8)	0.51
Orthopedic disease	35 (52)	14 (58)	0.61
Previous cerebral infarction	5 (7)	1 (4)	0.58
Body composition			
Metabolic rate (kcal)	1159 ± 135	1182 ± 138	0.48
Body mass index (kg/m ²)	23.3 ± 3.8	25.6 ± 5.4	0.03
Skeletal muscle mass (kg)	19.2 ± 3.8	19.8 ± 3.8	0.49
Body fat mass (kg)	17.5 ± 6.3	21.3 ± 8.5	0.02
Values are n (%) or means with standard deviations.			

Table 2
Multivariate factors related to the rise in body temperature.

	Odds ratio	95% CI	p value
Age (years)	1.06	0.95–1.19	0.26
Male	0.95	0.37–2.46	0.92
Baseline BMI ≥ 25 kg/m ²	0.82	0.19–3.49	0.79
Baseline body fat mass (kg)	0.95	0.86–1.05	0.35
Increase of skeletal muscle mass	4.77	1.29–17.70	0.02
Increase of metabolic rate	0.32	0.09–1.17	0.08
Note: BMI = body mass index; CI = confidence interval.			

Discussion

Body temperature is strictly regulated at the hypothalamus region because thermoregulation is crucial to human life [11]. Heat generation is consisted of metabolic heat production, skeletal muscle thermogenesis and physical activity. Elderly people have relatively low heat generation, impaired thermal perception and thermal regulatory response compared to young adults [4]. In addition, thermogenesis by meal intake is negatively affected by age because energy intake in the elderly tends to be lower than their energy expenditure, which results in gradual decrease of metabolic rate [12]. However, variation of metabolic rate exists independent of age and gender. A small number study showed a significant correlation between oral body temperature and metabolic rate in healthy participants [2]. A cohort study of 18630 participants aged 20–98 years showed a positive correlation between body mass index and body temperature both men and women in all generation [1]. These data indicate that diminished thermogenesis associated with lower metabolic rate and skeletal muscle mass cause decrease in body temperature in the elderly [13]. Moreover, reduction of meal intake accelerates weight loss and decreases skeletal muscle mass, resulting in further reduction of heat generation. In this study, lower body mass index and body fat mass were observed in lower body temperature group compared to normal body temperature. Brown adipose tissue has a thermogenic capacity and its main role is to preserve human body temperature [4]. Although amount of brown adipose tissue was not assessed in our study, lower body mass index and body fat mass may have contributed to lower the temperature in the lower body temperature group. However, body temperature rose significantly after 2-year of exercise training in the elderly with baseline body temperature < 36.3 °C. There was a strong correlation between baseline body temperature and the amount of rise in body temperature, indicating that 2-year exercise training resulted in higher degree of body temperature elevation in lower body temperature group. Participants with increase of skeletal muscle mass was significantly higher in lower body temperature group than that in normal body temperature group. Moreover, increase of skeletal muscle mass was an independent variable related to the rise in body temperature. Therefore, we consider that skeletal muscle mass rather than metabolic rate was strongly associated with the rise in body temperature after 2-year exercise training.

Several experimental studies have shown that rise in body temperature activates immune system which contribute to protect against infection and cancer [5–8]. CD8 + T cell activated by hyperthermia is capable of destroying virus-infected cells and cancer cells. Mace et al investigated activation of CD8 + T cell using mice with injected antigen, and found accelerated generation and differentiation of CD8 + T cell in warmed mice with 2 °C rise of body temperature [5]. Foxman et al demonstrated a close relationship between function of interferon and body temperature [6, 7]. More quick replicate and spread of common cold virus were observed in mouse airway cells in mice with lower body temperature due to impairment of interferon function. Although clinical significance of body temperature elevation was not evaluated in our study, rise in body temperature associated with increase in skeletal muscle mass after exercise training may have clinical benefits in the elderly with lower body temperature.

Two limitations of our study should be addressed. First, the study population was limited in number. The findings of this study need to be confirmed in a larger population to determine the clinical significance of rise in body temperature in the elderly. Nevertheless, this is the first study to evaluate the changes in body

temperature after exercise training in the elderly. Second, there is no data concerning muscle strength and functional testing such as grip strength and gait speed which is often used for sarcopenia diagnosis [14]. Further evaluation of relationship between body temperature and muscle strength and function is needed.

Conclusions

Body temperature rose after 2-year exercise training in the elderly, especially those with lower baseline body temperature.

Declarations

Ethics approval and consent to participate: An ethical approval was obtained from the Ethics Review Board of the Tsurumi Ryokuchi Hospital. Written informed consent was obtained from all participants.

Consent for publication: Not applicable.

Availability of data and materials: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Authors' contributions: KM, TI, SM and IS contributed to the study design. KM, IM, KT and HH contributed to participant recruitment and data collection. KM, KS, and JI performed data analyses. KM, T.Suga, T.Sugiua, and IS wrote the manuscript. All authors contributed to data interpretation, provided critical revisions of the manuscript, approved the final manuscript, and agreed to submit for publication.

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Figures

Figure 1

Change in body temperature after exercise training. Lower body temperature group (A) and normal body temperature group (B).

Figure 2

The amount of changes in body temperature after exercise training.

Figure 3

Correlation between change in body temperature after exercise training and baseline body temperature.

Figure 4

Comparison of participants with increase of skeletal muscle mass (A) and metabolic rate (B) after 2-year exercise training.