CHANGES IN FINGER COLD-INDUCED VASODILATION BETWEEN SKI-AND PHYSICAL-TRAINING

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Abstract

The present study aimed to examine the change cold-induced vasodilation(CIVD)of finger between seven female alpine(AP group)and six female cross-country skiers(CC group)at different points in their training programs. The CIVD test was performed twice, once in spring period after ski-training, once in the summer period during physical-training.

From the onset of ice-water immersion in each CIVD test, finger skin temperature in each group fell followed by an incline. Thereafter, finger skin temperature began to rise and fall in an attenuated fashion during ice-water immersion. The resistance index(RI)in summer(7.1 ± 1.7) for AP group was significantly($P < 0.01$)higher than that in spring(4.6 ± 1.1). However, that of CC group showed no difference between spring and summer.

These results suggested that the physical training during summer period for AP group may influence on the improvement of CIVD.

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key word : Cold-induced vasodilation(CIVD), female alpine and female cross-country skiers

Introduction

Cold-induced vasodilation(CIVD)in finger generally occurs 5~10 min after the start ice-water immersion of finger. From the onset of ice-water immersion, finger skin temperature fell followed by an incline. Thereafter, the rate of finger skin temperature began to rise and fall in an attenuated fashion during ice-water immersion. This reaction is related with arterio-venous anastomoses(AVAs)¹⁾. The activity of AVAs are suggested to play major role in the mechanism of CIVD²⁾. This phenomenon is believed to reduce the risk of frostbite. However, mechanism of CIVD is not clear .

Previous studies in CIVD to clarify the factors affecting local cold tolerance, such as gender, environment temperature³⁾, and menstrual cycle⁴⁾ have been conducted. Recent study in CIVD has reported that the finger skin temperature during ice-water immersion was maintained at a higher level in the athletes than non-athletes⁵⁾. Furthermore, the CIVD response has been reported to be improved by local cold acclimatization⁶⁾. The change CIVD of athletes is also estimated in various sports,

and outdoor competition showed a high local cold tolerance than an indoor competition⁷⁾. However, the effect of different training programs, such as ski-training on snow and physical fitness-training on CIVD was little known.

The present study aimed to examine the change of finger in CIVD between alpine and cross-country skiers at different points in their training program.

Methods

The measurement was basal body temperature (BBT)and the CIVD. BBT was measured every morning for 8 weeks from May to June. The measurement of CIVD was performed twice, once in spring period(May, after ski-training), once in the summer period(from July to August during physical fitness-training)

Subjects

The subjects in this study were seven female alpine(AP group)and six female cross-country skiers(CC group), aged from 18 to 22 years. The mean values of characteristics in AP and CC groups were as follows : Height of AP group 154.5 ± 2.8 cm ; weight 54.2 ± 8.5 kg ; body fat 24.9 ± 4.6 % ;

BMI, $22.7 \pm 2.8 \text{ kg/m}^2$; year of experience of sports 8.6 ± 4.3 years. Height of CC group $159.4 \pm 5.3 \text{ cm}$; weight $52.9 \pm 4.5 \text{ kg}$; body fat $24.1 \pm 2.4\%$; BMI, $20.9 \pm 1.3 \text{ kg/m}^2$; year of experience of sports 10.1 ± 4.3 years.

The AP and CC groups trained in cold environment during ski season (from November to the beginning of April). Training in ski season for AP group was ski technique, such as free ski-run and ski training on slalom courses. In contrast, the training in summer focused on the increasing physical fitness (muscular strength, including anaerobic and aerobic work capacity). Training of ski season in CC group was mainly the aerobic exercise combined improvement of ski technique, such as ski-run of about 30 km a day. In addition, the cross-country skier practiced the skating, kick and double polling to be necessary for a competition during ski-run. In summer, the training focused on improvement of aerobic power and technique (skating, kick and double polling) using a roller ski.

Protocol of CIVD test

CIVD was measured over 30 minutes after the subjects were rested for 30 minutes in an artificial climatic chamber at 22°C and 60% relative humidity. The several indexes of CIVD used in this study were based on the Yoshimura method⁸. A thermistor was attached to the dorsal side of the distal phalanx of the middle finger of the non-dominant hand,

white petrolatum was applied to prevent wetting, and the finger skin temperature was measured with the thermistor every 10 seconds before immersion and during immersion (30 minutes) in iced water (0°C).

Calculation

The temperature before water immersion (TBI), temperature at first rise (TFR), which is the temperature measured when the temperature began to recover from a nadir observed after immersion, time of temperature rise (TTR), which is the time from immersion to TFR, mean skin temperature (MST) during the 25 minutes from 5 to 30 minutes after immersion, and amplitude of temperature (AT), which was the difference between the minimum temperature during immersion and maximum temperature between 5 and 30 minutes after immersion, were determined as indices of CIVD. On the basis of these values, the resistance index (RI) was evaluated by a 5-point scale of Nakamura's method⁹.

Results

Figure 1 shows mean value of BBT of 8 weeks and experimental day for both groups (spring period). Mean value of BBT of 8 weeks (spring period) for AP group was $36.2 \pm 0.2^\circ\text{C}$ (from 35.4 to 36.5°C), and that for CC group was $36.4 \pm 0.1^\circ\text{C}$ (from 36.0 to 36.4°C). The BBT of the experimental day for AP group was $36.1 \pm 0.4^\circ\text{C}$ (from 35.2 to

Fig. 1. The mean values of basal body temperature for 8 weeks at experiment day in AP and CC groups (spring period). The secondary amenorrhea was shown three out of seven subjects in AP and two out of four subjects in CC group.

36.4°C), and that for CC group was $36.4 \pm 0.5^\circ\text{C}$ (from 36.0 to 37.0°C)

Figure 2 and 3 shows skin temperature during the CIVD test in AP and CC group of each period. From the onset of ice-water immersion in each CIVD test, finger skin temperature in each group fell. There-

after, the rate of finger skin temperature began to decline attenuated and changed into the incline or the decline during ice-water immersion. Finger skin temperature during ice-water immersion in summer for AP group was higher than that in spring(fig. 2) In contrast, the skin temperature in CC group

Fig. 2. Time course of middle finger temperature in the AP group before, during and after ice-water immersion in spring and summer periods. Values are mean.

Fig. 3. Time course of middle finger temperature in the CC group before, during and after ice-water immersion in spring and summer periods. Values are mean.

Table 1. Mean values of cold-induced vasodilation responses in spring period(May)after ski-training and the summer period(from June to July)during physical-training.

Period	Group	①TBI (°C)	②TFR (°C)	③TTR (min)	④MST (°C)	⑤AT (°C)	RI
Spring	AP	32.6±1.7	0.5±0.3	8.1±0.9	5.3±1.6	8.5±2.6	4.4±0.4
Summer	AP	32.4±1.5	2.0±1.0	7.2±0.6	8.5±2.0	10.8±3.2	7.1±1.7
			**	**	**	**	**
Spring	CC	32.9±1.2	1.1±0.6	7.0±0.6	8.5±2.6	12.6±3.6	6.5±1.0
Summer	CC	33.6±1.2	1.8±1.2	7.8±1.5	9.1±2.7	12.6±4.6	6.3±2.0

**p<0.01 : Significant difference between Spring and Summer periods. Values are mean±SD.

showed similar in both a periods(fig. 3)

Table 1 shows the parameters obtained from CIVD test based on Nakamura method⁹⁾. In the CIVD parameter of between spring and summer in each group, MST and TFR in summer for AP group were significantly(P<0.01)higher than that in 6spring. The time of TTR in summer for AP group was also significantly(P<0.01)shorter than in spring. However, there were no difference in CIVD parameter for CC group between spring and summer. RI in summer(7.1±1.7)for AP group was significantly(P<0.01)higher than that in spring(4.6±1.1). However, that of CC group showed no difference between spring and summer.

Discussion

Sugawara et al reported that MST and RI in luteal phase were significantly higher than that in follicular phase⁵⁾. In contrast, Moriya et al reported that the parameter of CIVD did not changed in follicular and luteal phase⁴⁾. In this study, the basal body temperature measured from May to June, but that from July to August was not measured. BBT of spring period in both groups showed no difference between the average of 8 weeks and experimental day. Continuous physical training is a factor to cause menoxenia such as secondary amenorrhea¹⁰⁾. In this study, the secondary amenorrhea was shown in four subjects in both groups during the experimental period. The effect of body temperature

changes during menstrual cycle on CIVD response may be much smaller.

Each parameter of CIVD for the AP group improved in summer period compared with spring period. Improvement of the CIVD response in AP group may be attributed to the following factors : training in ski season for AP group was ski technique, such as free ski-run and ski training on slalom courses. In contrast, the training in summer focused on the increasing physical fitness(muscular strength, including anaerobic and aerobic power). Therefore, the effect of training for physical fitness in summer period may be higher than that of ski season. The physical fitness-training during summer period for AP group may influence on the improvement of CIVD. The CC group showed either no significant difference between two periods. Training of ski season in CC group was mainly the improvement of ski technique, such as ski-run of about 30 km on a day. In addition, the cross-country skier practiced the skating, kick and double polling to be necessary for a competition during ski-run. In summer, the training focused on improvement of aerobic power and technique(skating, kick and double polling)using a roller ski. These training programs for CC group were similar in both two periods. The parameter of CIVD might be not significantly different in both periods. However, TFR and MST for summer period in CC group were also higher than spring period. From these results, aerobic training in sum-

mer period might strongly influence CVD response, such as TRF and MST.

Furthermore, a factor of influence on CVD showed acclimatization to cold. The CVD response has been reported to be improved by local cold acclimatization³⁾. In spite of off-season, AP group showed improvement of CVD in summer. It is suggested that physical training rather than acclimatization to cold strongly may influence on CVD.

In conclusion, each parameter of CVD for the AP group improved in summer period compared with spring period. These results suggested that the physical training during summer period for AP group may influence on the improvement of CVD. Furthermore, it is suggested that physical training rather than acclimatization to cold strongly may influence on CVD.

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