

## Effect of Wear Training on Temperature Adaptability of the Obese Children

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### 비만아동의 온도적응성에 대한 착용훈련 효과

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#### Abstract

This study was carried out to investigate the physiological responses of obese children after a short-term wear training and education. A ten-week program was conducted on thirteen obese elementary school children of six boys and seven girls in the 4th to the 6th grade. During the program, the children were instructed to measure daily ambient temperature and weight of their clothing. Physiological responses of the sedentary children in 100% cotton short sleeved t-shirt (0.13clo) and T/C short pants(0.09clo) were observed in the climatic chamber of  $23.0 \pm 0.5^{\circ}\text{C}$  and  $50 \pm 5\% \text{RH}$  before and after program. During the experiment, internal ear temperature( $T_{\text{ear}}$ ), seven site skin temperatures, systolic blood pressure, diastolic blood pressure, heart rate, and subjective responses of thermal comfort and thermal sensation were measured every 5minutes. Mean skin temperature( $T_{\text{sk}}$ ) and mean arterial pressure(MAP) were calculated. Obtained data are statistically analyzed and main results are as follows. There was highly significant correlation between the ambient temperature and the total clothing weight.  $T_{\text{ear}}$  and MAP were reduced in the post-program compared to the pre-program. The obese girls felt slightly warmer than the obese boys and the girls were likely to prefer lower ambient temperature in the post-program than the pre-program. It was concluded that the 10 week wear training is apt to be more applicable to the obese girls than the obese boys. However, a more comprehensive study including diverse measurements of deep body temperature with a long-term training would be needed to clarify the improvement of temperature adaptability in the obese children.

**Key words:** Obese children, Wear training, Temperature adaptability, Preferred temperature; 비만아동, 착용훈련, 온도적응성, 쾌적온도

### I. Introduction

Subcutaneous fat of the human body has been con-

sidered as one of the physiological factors to evaluate the adaptability to the cold environment. According to LeBlanc(1975), the layer of subcutaneous fat is one of the important factors in cold tolerance. As a result, the heat loss to the environment, which depends on the difference between temperature on the surface of the body and that of the environment, becomes much less important in fat man. Therefore,

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it is apparent that the subcutaneous fat must provide the major part of the body's insulation(Folk, 1974). In a study which compared skin temperature between thin adult and fat adult, skin temperature on the trunk of the body maintained lower in fat adult than thin adult due to the insulation of the body fat(Yoshizumi, 1994). In this point of view, the role of subcutaneous fat may replace that of the clothing, and vice versa, in the cold. From these facts, the subcutaneous fat seems to be closely related with men's wear habit of clothing in terms of temperature adaptability. In relation to this, however, Kim & Jeong(2000) observed that the obese children wore the same amount of clothing as the normal weight children during cold season.

On the other hand, adaptability to the temperature and the wearing behavior of clothing in obese children were observed in the previous study(Jeong et al., 2003). The obese children showed subjective response of the adaptability to the cold and the heat differently from the normal weight children. In other words, obese children were more susceptible to the heat, whereas they were less susceptible to the cold than normal weight children. Moreover, the development of educational program for wearing behavior of obese children was requested(Jeong et al., 2004). Consequently, there is no question that an educational and/or training program for proper wearing habits of the obese children is necessary to be carried out in terms of temperature adaptability.

In this study, therefore, physiological responses based on the temperature adaptability were investigated in obese children after short-term wear training and education.

## II. Materials and Method

### 1. Educational Training Program

A ten-week program was conducted on thirteen obese elementary school children of six boys and seven girls in the 4th to the 6th grade. The program consisted of diverse styles of education for improving the quality of living habits such as wearing, eating, physical exercise, etc.(Jeong et al., 2005). In relation to wear training, the children were weekly edu-

cated on the way of wearing clothes during the program in order to improve the temperature adaptability. They were also instructed to measure daily the ambient temperature in their house and the weight of clothing worn by themselves during stay in their houses.

### 2. Experiment

Before and after operating the program, sedentary physiological responses were observed through the experiment. The experiment was carried out in the climatic chamber controlled at  $23.0 \pm 0.5^{\circ}\text{C}$  and  $50 \pm 5\% \text{RH}$ . After the children entered the chamber, they answered dozens of questions related to their living habits including wearing behavior and temperature adaptability, etc. for about 20minutes. After the questionnaire, they changed from their clothes into the experimental clothes of 100% cotton short sleeved t-shirt(0.13clo) and T/C short pants(0.09clo) over their own underwears. They sat in a comfortable chair being equipped with the experimental apparatuses and their physiological responses were observed for 30minutes. Thermally comfortable temperature, defined as 'preferred temperature' in this study, was chosen by the children themselves at the end of the experiment.

Height, weight, and body fat of the children were measured using InBody 3.0(Biospace, Co. Ltd., Korea). During the experiment, physiological parameters-such as internal ear temperature( $T_{\text{ear}}$ )(Thermo Scan, IRT 3020, Braun Co., Germany), temperature of the seven sites on the skin(Hybrid Recorder, K370, Technol Seven Co., Japan), systolic and diastolic blood pressures with heart rate(Automatic Sphygmomanometer, Korea)-were measured every 5 minutes. Subjective responses were also measured every 5minutes in thermal comfort with four scales(1: comfortable, 2: slightly uncomfortable, 3: uncomfortable, 4: very uncomfortable) and in thermal sensation with nine scales(1: very hot, 2: hot, 3: warm, 4: slightly warm, 5: neutral, 6: slightly cool, 7: cool, 8: cold, 9: very cold).

Mean skin temperature( $T_{\text{sk}}$ ) was calculated from the seven site(head, chest, forearm, hand, thigh, leg, foot) skin temperatures and mean arterial pressure

(MAP) was calculated from systolic and diastolic blood pressures using the following equations, respectively.

$$T_{sk}(^{\circ}\text{C}) = (0.07 \times T_{\text{head}}) + (0.05 \times T_{\text{hand}}) + (0.13 \times T_{\text{leg}}) + (0.07 \times T_{\text{foot}}) + (0.35 \times T_{\text{chest}}) + (0.14 \times T_{\text{arm}}) + (0.19 \times T_{\text{thigh}})$$

$$\text{MAP}(\text{mmHg}) = \{\text{systolic blood pressure} + 2(\text{diastolic blood pressure})\} / 3$$

### 3. Statistical Analysis

Obtained data were statistically analyzed using independent-samples t-test and paired t-test, and Pearson's correlation in SPSS 12.0 for Windows. Difference of the experimental results in pre-program vs. post-program and boys vs. girls was significant

at  $p < .05$  or  $p < .01$ . And the difference showed tendency at  $p < .1$ .

## III. Results and Discussion

During the ten weeks of the program, average ambient temperature in the house was  $25.1^{\circ}\text{C}$  and average clothing weight divided by the surface area of the obese children was  $300\text{g}/\text{m}^2$ . There was highly significant correlation between the ambient temperature and the total weight of clothing per body surface area (BSA) ( $r = -0.917, p = .000$ ). The result revealed that the children put on their daily clothes according to the ambient temperature, which may be due to the effect of wear training.

The physical characteristics are shown in <Table 1>. Body weight of the children was reduced while their

**Table 1. Change of physical characteristics in the obese children after 10 weeks of education and training**

Children	Total		Boys		Girls	
	Pre	Post	Pre	Post	Pre	Post
Height (cm)	148.1±2.2	149.2±2.2**	148.0±1.8	149.1±1.8*	148.1±4.0	149.2±4.0**
Weight (kg)	57.1±2.8	56.4±2.8*	57.9±3.2	57.6±2.8	56.3±4.7	55.4±4.9*
BSA (m <sup>2</sup> )	1.50±0.05	1.50±0.05	1.51±0.05	1.51±0.04	1.49±0.08	1.49±0.08
Body fat (%)	37.3±1.0	35.4±0.9**	37.4±2.0	35.5±2.0 <sup>+</sup>	37.2±0.9	35.3±0.7*

Values are mean±SE, <sup>+</sup> $p < .1$ , \* $p < .05$ , \*\* $p < .01$  compared to the pre-program.

**Table 2. Physiological responses of the sedentary obese children in the pre-program and the post-program**

Children	Total		Boys		Girls	
	Pre	Post	Pre	Post	Pre	Post
T <sub>ear</sub> (°C)	36.9±0.1	36.6±0.1**	36.9±0.2	36.6±0.1*	36.9±0.2	36.5±0.1 <sup>+</sup>
T <sub>sk</sub> (°C)	29.5±0.4	29.5±0.4	29.8±0.9	29.9±0.9	29.3±0.3	29.0±0.2
T <sub>head</sub> (°C)	34.3±0.1	34.1±0.1 <sup>+</sup>	34.2±0.2	34.1±0.1	34.5±0.1	34.1±0.1 <sup>+</sup>
T <sub>chest</sub> (°C)	33.7±0.3	33.2±0.3	33.4±0.3	33.2±0.4	34.0±0.6	33.1±0.4
T <sub>arm</sub> (°C)	30.9±0.3	30.4±0.1	30.8±0.7	30.5±0.1	31.0±0.2	30.3±0.2 <sup>+</sup>
T <sub>hand</sub> (°C)	32.3±0.3	32.7±0.2	31.9±0.6	32.9±0.4	32.5±0.3	32.5±0.1
T <sub>thigh</sub> (°C)	33.1±0.3	33.1±0.2	33.1±0.5	33.1±0.2	33.1±0.3	33.1±0.3
T <sub>leg</sub> (°C)	30.2±0.4	30.3±0.1	30.2±0.8	30.1±0.2	30.1±0.2	30.4±0.2*
T <sub>foot</sub> (°C)	31.6±0.6	32.6±0.3 <sup>+</sup>	31.3±0.2	32.4±0.7	32.0±0.6	32.8±0.3
MAP (mmHg)	82.1±2.3	70.3±2.1**	85.0±3.8	70.0±3.4**	79.6±2.8	70.6±2.8*
HR (bpm)	80.0±3.0	77.9±3.3	75.9±4.4	72.8±4.4	83.5±3.7	82.1±4.3
Thermal comfort	1.2±0.1	1.1±0.1	1.3±0.2	1.0±0.0	1.1±0.1	1.1±0.1
Thermal sensation	4.6±0.2	4.7±0.2	4.7±0.4	5.1±0.1	4.6±0.3	4.3±0.3

Values are mean±SE. <sup>+</sup> $p < .1$ , \* $p < .05$ , \*\* $p < .01$  compared to the pre-program.

height was increased in the post-program compared to the pre-program. In addition, percent body fat of the children was reduced 1.9% from the pre-program to the post-program with larger deviation in boys than girls. Reduced body fat might be due to the combination effect of dietary training and physical exercise rather than wear training itself.

<Table 2> shows the physiological responses of the obese children during the experiment. Average  $T_{\text{ear}}$  was reduced  $0.3^{\circ}\text{C}$  in the post-program compared with the pre-program. Although  $T_{\text{sk}}$  was not changed according to the program, it seemed that peripheral parts of the skin was higher and proximal parts was lower in the post-program compared to the pre-program in most cases. Among the peripheral skin temperatures, it was worthy of notice that foot skin temperature increased  $1^{\circ}\text{C}$  ( $p=.054$ ) in the post-program, which generally might cause  $T_{\text{ear}}$  to be lowered compared to the pre-program. On the other hand, lower  $T_{\text{ear}}$  with lower body fat in the post-program (<Table 1> and <Table 2>) may be supported by the fact that men with high fat body composition maintain higher core temperature than their low fat counterparts (Glickman-Weiss et al., 1999). However, diverse measurement of the internal body temperature would be needed for its credibility. MAP was also reduced in the post-program, which might be due to the 10 week training of physical exercise. The children felt thermally comfortable and neutral during the experiment. There were no significant differences of subjective responses between pre-program and post-program. As for the gender difference, however, the girls felt slightly warmer than the boys in the post-program ( $p=.047$ ) while there was no significant gender difference of thermal sensation in the pre-program.

<Fig. 1> shows the comfortable ambient temperature chosen by the children. Although thermal comfort and thermal sensation did not show any significant differences between pre-program and post-program (<Table 2>), it is apparent that the preferred temperature was affected by the 10 week training. Unlike the boys, the girls were likely to prefer the ambient temperature  $0.3^{\circ}\text{C}$  lower in the post-program than the pre-program ( $p=.086$ ). With the fact that the

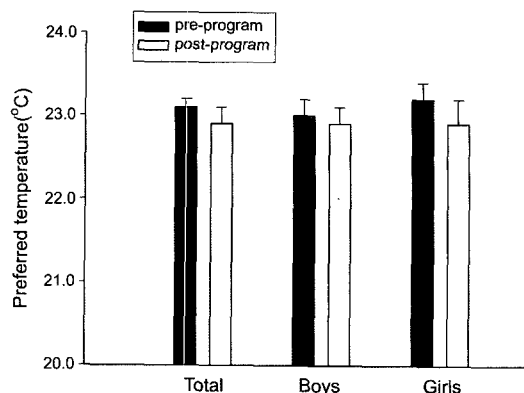


Fig. 1. Thermally comfortable temperature chosen by the obese children. Difference of the preferred temperature between pre-program and post-program shows tendency in the girls ( $p=.086$ )

girls felt slightly warmer than the boys in the post-program (<Table 2>,  $p=.047$ ) as mentioned above, it can be concluded that the obese girls were more susceptible to the temperature than the obese boys. These results suggested that at least the obese girls must keep trying to wear clothes which adapt to the ambient temperature in terms of improvement of temperature adaptability.

#### IV. Conclusion

It was concluded that the 10 week wear training is apt to be more applicable to obese girls than obese boys. Experimental data would be useful in understanding behavioral and autonomic temperature regulation of the obese children. However, a more comprehensive study including diverse measurements of deep body temperature with a long-term training would be needed to clarify the improvement of temperature adaptability in the obese children.

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## 요 약

본 연구에서는 비만아동의 온도적응능력을 향상시키기 위해 초등학교 4학년~6학년에 재학 중인 비만 아동 13명(남자 6명, 여자 7명)을 대상으로 하여, 10주간의 단기 의복착용훈련 프로그램을 시행한 후 프로그램의 효과를 알아보았다. 프로그램 시행기간 중 아동이 매일 직접 측정된 주택 내 실내온도는 평균 25.1°C였고, 아동이 착용한 체표면적당 의복의 무게(착의량)는 평균 300g/m<sup>2</sup>였으며, 실내온도와 착의량 간에는 유의한 상관이 있었다( $p < .01$ ). 프로그램의 시행효과를 구체적으로 알아보기 위해, 23.0±0.5°C, 50±5%RH로 조절된 인공기후실에서 실험을 실시하여, 반소매 면 티셔츠(0.13clo)와 T/C 반바지(0.09clo)를 착용하고 안정상태에 있는 아동의 체온, 피부온, 혈압 및 맥박 등의 생리반응과 쾌적감 및 온랭감의 주관적 감각반응을 프로그램 시행 전후에 측정한 후 얻은 주요 결과는 다음과 같다. 평균피부온은 프로그램 시행전후에 유의한 차이가 없었으나, 전반적으로 체온과 평균혈압은 프로그램 시행 후에 내려갔다( $p < .01$ ). 주관적 감각반응에서는 프로그램 시행 후에 여아가 남아에 비해 약간 더 따뜻하게 느꼈고( $p < .05$ ), 이에 따라 아동자신이 선택한 쾌적온도는 더 낮은 경향을 나타내었다( $p < .1$ ). 이와 같은 연구결과는 비만아동의 행동성 및 자율성 체온조절연구에 유의할 것이나, 보다 명확한 자료를 얻기 위해서는 종합적이고 장기적인 훈련프로그램의 시행이 요구된다.