[Transaction]

Journal of the Korean Society
of Clothing and Textiles
Vol. 29, No. 12 (2005) p.1527~1534

Thermo-physiological Responses of the Lower Grade Elementary School Children
-A Comparison Between Japanese and Korean Children-

Seong-Hee Kim† · Uk-Ja Lee* · Teruko Tamura**

Dept. of Clothing &Textiles, Chonnam National University,
*Dept. of Clothing &Textiles, Keimyung University,
**Home Economics, Bunka Women's University

초등학교 저학년 아동의 체온조절반응
-일본아동과 한국아동의 비교-

김성희† · 이욱자* · 田村照子**

전남대학교 의류학과, *계명대학교 의류학과, **文化女子大學 服裝學部

(2004. 9. 18. 접수)

Abstract

In order to clarify the characteristics of the thermo-physiological responses of the child and to understand the influence of the country where the child has grown up on the responses, the thermo-physiological responses of the Japanese children(J group) and the Korean children(K group) were examined. The subject wearing shorts was exposed first to a thermo neutral room(Ta=28.5°C) for 1 hour, then transferred to a cold(Ta=22°C) or a hot(Ta=37°C) room for 1 hour. The experiment was done in the climate chamber of Bunka Women's University in the summer of 1997 for Japan, and in the climate chamber in the Keimyung University in the summer of 1998 for Korea. The subjects consisted of 5 boys and 5 girls aged 7-9 years in Japan and 4 boys and 4 girls aged 7-9 years in Korea. As a result: 1) The rectal temperature increased slightly with a rise in air temperature. K group showed a slightly higher rectal temperature. 2) The skin temperature of the hand and foot decreased conspicuously during cold exposure. It was more in the K group than in the J group. 3) Relative local sweat rates were similar in the two groups at 22°C and 28.5°C, while they were considerably different at 37°C. Even perspiration was observed over the whole body in the J group but the perspiration was large in the trunk and low in the extremity in the K group. 4) The heart rate was higher in the J group than in the K group but it increased with the rise of the air temperature in both groups.

Key words: The lower grade elementary school children, Thermo-physiological responses, Cold room, Heat room; 초등학교 저학년, 체온조절반응, 추운환경, 더운환경

I. Introduction

Many studies have reported about the relation between climate and thermoregulatory responses. Most studies have been conducted on adults but few researches have been done on primary school students. Concerning the child's thermoregulatory responses according to the season, Tanaka(1952a, 1952b) reported that an oral and tympanic temperature of the child was higher than that of the adult in

†Corresponding author
E-mail: ksh5088@yahoo.co.kr

the summer afternoon. In addition, the mean skin temperature of boy's and girl's forehead, chest, and leg is low in the order of spring, summer, winter and autumn, and had a significant difference between autumn and spring/summer(Tanaka, 1952c). As for perspiration, according to Shibasaki(1997), the perspiration quantity per sweat gland is less at the boy's chest, back, thigh, and forehead compared to that of the adult under hot environment. That is, the child's perspiration reaction is not greater than that of the adult. As for this, Falk et al.(1992, 1998) observed that the sweat gland and perspiration quantity per body surface area increased with maturation for the boy in exercise.

In relation to the children's thermoregulatory responses to cold stress when air temperature dropped linearly from 28°C to 15°C, the rectal and skin temperature of the boys became significantly lower than? that of the men, especially on the limbs such as the thigh and forearm(Inoue et al., 1996). According to Inoue et al., boys' heart rate in the equilibrium period was significantly greater than that of the men. However, there was no significant difference between these groups in terms of decrease in the heart rate with decreasing air temperature.

According to the above report, the children have the thermoregulatory responses that are different from the adult. But there are few measurement parts in any research and the subject of the experiment is focused on the boy. In addition, the report on the perspiration showed the thermoregulatory responses during exercise. Therefore, further investigation is needed to examine the thermoregulatory responses in the children including a girl in the equilibrium period.

On the other hand, Nagata(1954) reported that dressing habit has an influence on basal metabolic rate and made it clear that dressing habit is closely related to thermoregulatory responses. The Japanese and Korean who have yellow skin and live in the similar climate form a different culture and habits. For example, as for the dwelling environment, Japan has the habitude to use the TATAMI for the floor in Japan, but Korea does not have such habitude to use that. In addition, through the education and so on the child in Japan learns to rarely put on clothes, whereas there is no such habitude in Korea. What influence will the difference in such growth environment condition have on the thermoregulatory responses of the child We have an interest in seeing how the children in Korea and Japan have differences in relation to thermoregulatory responses.

Both to clarify the characteristics of the thermo-physiological responses of the child and to understand the influence of the child's native country on the responses, the thermo-physiological responses of the Japanese children(J group) and the Korean children(K group) were examined. This study was conducted to investigate the thermo-physiological responses of prepubertal children during neutral-cold exposure and -heat exposure.

II. Methods

1. Subjects

Subjects in the experiment consisted of 5 boys and 5 girls aged 7-9 years who live in Kanto district in Japan, as well as 4 boys and 4 girls aged 7-9 years who live Dea-Gu City in Korea. The J group has rather more than average height(123.8cm) and weight (25.1kg) in comparison with the same age group in Japan whose average age is 7.9. The K group has more than average height(129.7cm) and weight (28.9kg) in comparison with the same age group in Korea whose average age is 9.0(Table 1). The average age of the K group is 1.1 years old higher than the J group and the physique is rather more excellent than the J group in terms of the height, the weight and BMI. Prior to measurement, the subjects and the children's parents were debriefed about the research and then given written information about the research procedures and possible risks involved in the study. Written informed consent was obtained from both the subjects and their parents.

2. Experimental Condition

Thermo-physical responses of J group were examined in a climate chamber at Bunka Women's University in July and August of 1997. The test for K

Table 1. Physical characteristics of the subjects

		Age(yrs)	Height(cm)	Weight(kg)	BSA(m^2)	BMI
Japan	AVG	7.9	126.4	28.2	1.0	17.6
	S.D.	0.7	8.3	5.5	0.1	2.3
	Standard		123.8	25.1	0.9	16.4
Korea	AVG	9.0	131.2	31.8	1.0	18.4
	S.D.	0.8	5.1	6.4	0.1	3.1
	Standard		129.7	28.9	1.0	17.2

BSA: Body surface area estimated by the method of Fujimoto et al.(1968)
BMI: Body Mass Index
Standard: Japan - (Research institute of human engineering for quality life - Japanese body size data 1992~1994)
Korea - (The Korean society of pediatrics 1998)

group was conducted in a climate chamber at the Keimyung University in July and August of 1998. The experiment was conducted over 2 days per one subject and began at 9:30 a.m. or 1 p.m. Each subject wearing shorts was sitting down and watching animations, so as not to get him/her tired from the long test. The subjects were exposed first to a thermo-neutral room (air temperature (Ta) 28°C, relative humidity (RH) passive) for 1 hour, and then exposed a cold room(Ta 22°C, RH 5010%.) or a hot room(Ta 37°C, RH 5010%) for 1 hour.

3. Procedure and Measurement

The procedure and the measurement are shown in (Fig. 1). During the test, rectal temperature was continuously measured with thermocouple thermometer for J group, and for K group with a thermistor thermometer. The rectal probe was inserted 12cm deep into the anus of children.

Skin temperature was measured at four sites(the forehead, the chest, the finger, and the toe) using the thermocouple thermometers which was taped to the skin, and the skin temperature was measured using a thermo camera in J group at the front, the side, and the back. The skin temperature was measured at seven sites(the forehead, the chest, the upper arm, the thigh, the leg, the finger and the toe) using the thermistor thermometers in K group.

Local sweat rate was measured every 2 seconds for 30 seconds on one measuring point by an evaporimeter(type EP-ID, Sankou Co., Japan) and computed

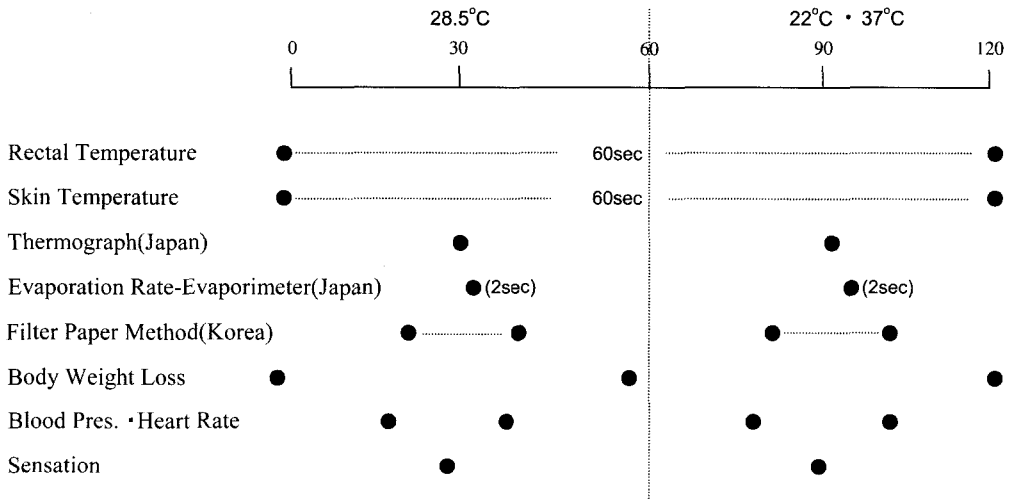

Fig. 1. Procedure of the experiment

the average of 6 data in the latter half of the data set in J group. In K group, it was measured for 20 minutes after 20 minutes of each exposure by filter paper method(three pieces of filter paper(2cm×3cm) attached to the skin). The measurement sites in both groups consisted of 13 body parts that including the forehead, the chest, the abdomen, the back, the buttock, the upper arm, the forearm, the hand, the palm, the thigh, the leg, the foot, and the sole.

Blood pressure and heart rate in both groups were measured using an automatic tonometer(type HEM-737, Omron Co., Japan). They were measured three times at the 20th minute and the 40th minute, respectively, after each exposure and the study looked for the average in the measurement.

III. Results

1. Rectal Temperature and Skin Temperature

<Fig. 2> shows the rectal temperature plotted after 50 minutes of each exposure in J group and K group. The rectal temperature increased slightly with a rise in air temperature in both groups. According to the analysis of variance, it was significantly greater in the K group than in the J group.

<Fig. 3> shows the relationships between skin temperature and air temperature after 50 minutes of each exposure in J group and K group. Skin temperature on the forehead and the chest increased with a rise in air temperature, but the skin temperature on the finger and toe increased rapidly in air temperature from 20°C to 30°C and then didn't increase beyond that because of vasoconstriction and vasodilation by arteriovenous anastomoses. Therefore, the relational with the environmental temperature was a secondary curve, respectively.

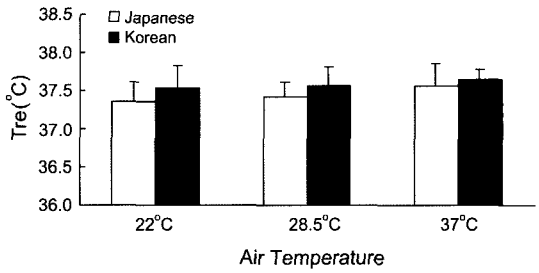

Fig. 2. The relation between the air temperature and the rectal temperature for Japanese and Korean children

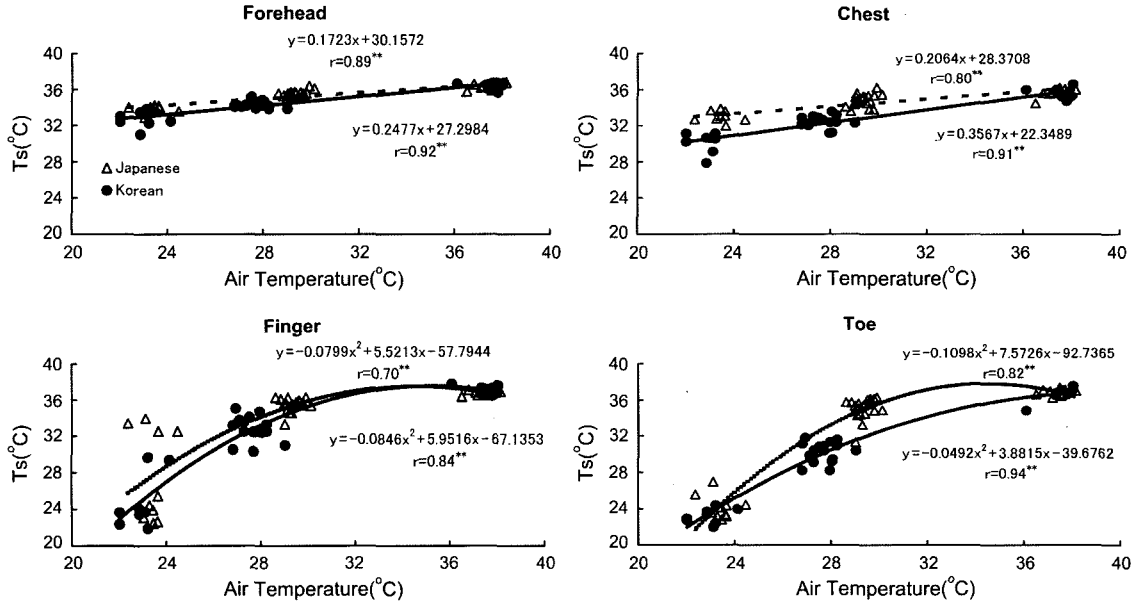

Fig. 3. The relationships between the air temperature and the skin temperature on forehead, chest, finger and toe in the Japanese and Korean children.

2. Local Sweat Rate

<Fig. 4> shows the comparison on the relative value of the local sweat rates at 37°C air temperature; the measurement of those was different but the experimental condition was the same in both groups. The relative local sweat rates were similar in two groups at 22°C and 28.5°C, and it was proved that both measurements were reasonable judged by relative values. In both groups, the relative local sweat rates in the palm and the sole which show mental perspiration at 22°C, 28.5°C were the highest, but they were considerably different at 37°C. Even perspiration was observed by the range of 8±3% over the whole body in the J group, but the perspiration was large by the range of 10.5 ~ 16.6% in the trunk (the forehead, the chest, and the back) and low by the range of 3.3~ 6.6% in the extremity in the K group.

3. Blood Pressure and Heart Rate

According to analysis of variance, blood pressure did not change with the air temperature in both groups and there was no difference between two groups.

The heart rate was 81.82 beat/min - 89.43 beat/min - 99.37 beat/min at 22 - 28.5 - 37°C in the J group, it was 75.92 beat/min - 84.11 beat/min - 94.82 beat/min at each exposure in the K group. The correlation between the heart rate and the air temperature was significant in both groups and the heart rate increased according to a rise in air temperature. The heart rate was significantly greater in the J group than in the K group at each exposure.

IV. Discussion

Falk et al.(1992) showed the change of thermoregulation accompanying the increase in age. They reported that rectal, skin temperature, and heart rate of boy's group(aged 12, 13, 16) were high in late-pubertal boy during exercise at hot exposure. And they observed that population density of the heat-activated sweat glands decreased with age in groups of boys aged 10, 13, 16, but sweat rate per gland increased with age. This research examined the difference in thermoregulatory responses according to the subjects' ages because the subjects' ages range from 7 to 9 years. However, analysis of variance in rectal temperature, skin temperature, and sweat rate and so on showed that there were no significant differences according to the age, while there was the range of difference among individuals in each J group and K group.

The rectal temperature in both groups decreased slightly at the cold exposure and increased slightly at the hot exposure. On the other hand, concerning the rectal temperature of the adult, there was no change in the rectal temperature at the cold exposure(Inoue et al., 1996), and the rectal temperature increased slightly at the hot exposure like in the case of the child(Shibasaki et al., 1997). It makes the children increase metabolism at the cold exposure like in the case of the adult but the rectal temperature of them

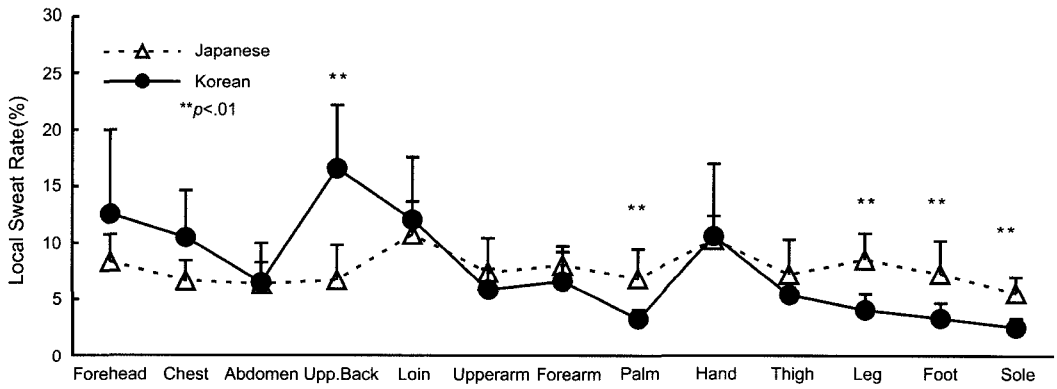

Fig. 4. The comparison of the relative local sweat rate of the Japanese and Korean children at 37°C air temperature

falls because the heat loss is greater than the increased metabolism. It is easy for the children not only to take the heat in the hot environment but also lose the heat in the cold environment than the adult, because the ability to maintain rectal temperature of the children immature and the surface-area-to-mass ratio of them is bigger than the adult(Bar-Or et al., 1989; Falk et al., 1998). K group showed a slightly higher rectal temperature and maintained rectal temperature to the change of the environment temperature rather than the J group did. It was suggested that the possibility contributes to thermoregulatory responses of the K group, that the physique of the K group is rather more excellent than the J group, that it was not a significant difference, or that it was the thing with a low of 3 ~ 5°C in the air temperature of winter in Korea, and so on.

The skin temperature of the finger and toe changed according to the air temperature. As a result, the skin temperature in the J group and K group suddenly declined when the environment changed from the thermoneutral to the cold. Inoue et al.(1992) have reported on vasoconstriction of the children that compared to the young men, the decrease in skin temperature was significantly greater for boys especially on the limbs in the cold environment. This is because vasoconstriction on the peripheral is excellent for boys than the young men. There is no correlation between skinfold thicknesses and surface area-to-mass. Also, Smolander(1992) and Falk(1997) are reporting a similar result. Previous studies support the results of present study. Compared to J group, the temperature of the finger and toe was lower in the K group under the cold stress. Accordingly it is possible that the vasoconstriction on the peripheral for the K group was somewhat more excellent than the J group.

Even perspiration was observed over the whole body in the J group whereas the perspiration was large in the trunk and low in the extremity in the K group. Kuno(1963) reported that the perspiration for the adult individual differed according to each individual, that a sixth out of 105 subjects has perspiration over the whole body and the rest have little perspiration in the extremity, and that both sides of forehead, neck, and trunk and forearm and hand are easy to evaporate because of their exposure to the outside environment. Shibasaki et al.(1997) reported that in relation to the children the local sweat rate on the forearm and the thigh were lower than on the back and the chest when the subjects' legs are placed into a 42°C water bath at 25°C. In addition, Tsuzuki et al.(1995) showed that concerning the child, the local sweat rate on the back was greater than on the upper arm at 35°C. Most studies report that the sweat rate on the trunk was greater than on the extremity. As a result, the distribution type of the K group of this study is supported. However, in consideration of the small number of the measurement parts and the different experiment conditions in the previous studies, it cannot be concluded that the uniform distribution type of evaporation in the J group indicates certain characteristics of the child. More study is needed in relation to the local sweat rate of the child.

The results show that in both groups increase of the blood pressure and decrease of the heart rate were based on vasoconstriction at the cold exposure, and that decrease of the blood pressure and increase of the heart rate were based on vasodilation at the hot exposure. Toselli et al.(1997) examined the school children aged 6 to 14 years and showed that there was a strong relationship between systolic blood pressure and BMI, and that systolic blood pressure increased with an increase in BMI. However the present study results do not show that there is a clear relationship between BMI and systolic blood pressure. Araki(1980) compared physically trained children with untrained children by exposing them to heat and cold stress alternately. The results showed that the heart rate tended to be lower in trained children. The result of this study shows that the heart rate is somewhat lower in the K group than in the J group. Such results may have come from the difference in the activity degree of the subjects in both K and J group.

The study examined the thermo-physiological responses of the children with the same age in Japan and Korea to thermoregulation in both countries in the same season but differing in the year in order to know whether the children have a different ther-

moregulation or not, and how they differ in terms of responses to thermoregulation. In spite of the fact that research facilities and instruments in both countries were different and the fact that the average age differed by one in both countries, the study results showed that the responses of children in both countries to thermo-physiological responses were fairly similar, thus statistically produce no significant difference. However the study results generally show that compared to the subjects in Japan, the subjects in Korea have a rather high rectal temperature, a decreasing skin temperature, the high local sweat rate in the trunk but less high local sweat rate in the extremity, low heart rate, and a significant change in the blood pressure. The results show that the children in Korea have a more adaptability to the environment in comparison with the children in Japan. Future studies need to increase the subjects in the experiment to draw significant results. Based on the present study results, the authors will examine more the relationship between the living culture such as the clothing, eating habits, and residence with the children's adaptability to the environment.

V. Conclusion

In order to clarify the characteristics of the thermo-physiological responses of the child and to understand the influence of the country where the child has grown up on the responses, the thermo-physiological responses of the Japanese children and the Korean children were examined. As results, 1) The rectal temperature increased a little with the air temperature rise. K group showed a little higher rectal temperature. 2) The skin temperature of hand and foot decreased conspicuously during cold exposure. It was more in K group than in J group. 3) Relative local sweat rate were similar in two groups at 22°C and 28.5°C, while they were considerably different at 37°C. Even perspiration was observed over the whole body in J group but the perspiration was large in the trunk and low in the extremity in K group. 4) The heart rate was higher in J group than in K group but it increased with the rise of the air temperature in both groups.

References

Araki, T., Tsujita, J., Matsushiita, K., & Hori, S. (1980). Thermoregulatory responses of prepubertal boys to heat and cold in relation to physical training. *J Human Ergol, 9*, 69–80.

Bar-Or, O. (1989). Temperature regulation during exercise in children and adolescents. In C. V. Gisolfi, & D. R. lamb (Eds.), *Perspective in exercise science and sports medicine: Vol II. Youth, exercise, and sports* (pp. 335–362). Indianapolis: Benchmark Press.

Falk, B. (1998). Effects of thermal stress during rest and exercise in the paediatric population. *Review article, Sports Med, 25*(4), 221–240.

Falk, B., Bar-Or, O., Calvert, R., & Macdougall, J. D. (1992). Sweat gland response to exercise in the heat among pre-, mid-, and late- pubertal boys. *Med Sci Sports Exerc, 24*(3), 313–319.

Falk, B., Bar-Or, O., & Macdougall, J. D. (1992). Thermoregulatory responses of pre-, mid-, and late- pubertal boys to exercise in dry heat. *Med Sci Sports Exerc, 24*(6), 688–694.

Falk, B., Bar-Eli, M., Dotan, R., Yarron, M., Weinstein, Y., Epstein, S., Blumenstin, B., Einbinder, M., Yaron. Y., & Tenenbaum, G. (1997). Physiological and cognitive responses to cold exposure in 11-12-year-old. *Am J Hum Biol, 9*, 39–49.

Fujimoto, S., & Watanabe. (1969). Studies on the body surface area of Japanese. *Acta Med Nagasaki, 13*, 1–13.

Inoue, Y., Araki. T., & Tsujita, J. (1996). Thermoregulatory responses of prepubertal boys and young men in changing temperature linearly from 28 to 15°C. *Eur J Appl Physiol, 72*, 204–208.

Kuno, Y. (1963). *The story of sweat.* Tokyo: Koseikan.

Shibasaki, M., Inoue, Y., & Kondo, N. (1997). Mechanisms of underdeveloped sweating responses in prepubertal boys. *Eur J Appl Physiol, 76*, 340–345.

Nagata, H. (1954). As for the influence that the dressing habit exerts on basal metabolic rate. *Environ Health Prev Med, 26*, 1–29.

Tanaka, H. (1952a). Seasonal variation in the basal temperature of school-children in kumamoto district. *Res Physical Education, 3*(1), 67–70.

Tanaka, H. (1952b). Seasonal observation of body temperatures of school-children during school hours. *Res Physical Education, 3*(1), 71–77.

Tanaka, H. (1952c). Seasonal variation in skin temperatures of school children in kumamoto district. *Res Physical Education, 3*(1), 52–56.

Toselli, S., Graziani. I., Taraborelli, T., Grispan, A., Tarsitani, G., & Grupppioni, G. (1997). Body composition and blood pressure in school children 6-14 years of age. *Am J Hum Biol, 9*, 535–544.

요 약

본 연구는 아동의 체온조절반응의 특징에 성장환경이 어떠한 영향을 미치는가를 명확히 하기위해, 한국아동(K group)과 일본아동(J group)의 체온조절반응을 검토하였다. 팬츠 착용의 피험자는 중립환경(28.5°C)에서 1시간, 추운환경(22°C) 또는 더운환경(37°C)으로 옮겨져 1시간 동안의 체온조절반응이 검토되었다. 그 결과, 직장온은 환경온이 높아짐에 따라 약간 높아졌으며, K group의 직장온이 J group보다 약간 높았다. 추운환경에서의 손과 발의 피부온은 현저히 저하되었으며, J group보다 K group에서 더 현저히 나타났다. 그리고, 두 group의 절대 국소 증발량은 환경온 22°C와 28.5°C에서 비슷한 분포를 나타내는 반면, 환경온 37°C에서는 J group은 몸전체에서 발한을 나타냈으나 K group은 사지보다 몸통부위의 발한량이 많았다. 맥박은 환경온의 상승에 따라 높아졌으며, J group의 맥박이 K group보다 더 높았다.