Brief Paper:

Characteristics of Low Body Temperature in Secondary School Boys

Shingo Noi*, Haruo Ozawa**, and Takeo Masaki*

*Nippon Sport Science University
7-1-1 Fukasawa, Setagaya-ku, Tokyo 158-8508 Japan
E-mail: nois@nittai.ac.jp

**Komaba Secondary School attached to Tsukuba University
4-7-1 Ikejiri, Setagaya-ku, Tokyo, 154-0001 Japan

[Received December 31, 2002; accepted January 17, 2003]

The purpose of this study was to verify the relationship of the occurrence of low body temperature at rising time and intraday body temperature changes, rising time, going-to-bed time, exercise hours, heart rate at rising time, and intrinsic motivation for attending school at rising time. The subjects, 452 healthy junior and senior high school male students, were divided into two groups, namely, Average group (AG) with an axillary temperature above 36.0 and below 37.0 at rising time and Low group (LG) with an axillary temperature below 36.0. The temperature was taken on a weekday without physical exercise classes in school in June 1999 and in the same month in 2001. The level of intraday body temperature of LG was lower than that of AG. The body temperature of AG reached its peak around noon, but that of LG peaked around 4 o’clock in the afternoon. The body temperature at going-to-bed time of LG did not get lower to the level at rising time. The heart rate of LG (66.6 ± 9.0 beat*min⁻¹) was significantly lower than that of AG (70.9 ± 10.7 beat*min⁻¹). The intrinsic motivation for attending school of LG (3.0 ± 1.1 points) was significantly lower than that of AG (3.6 ± 1.2 points). Those with the above motivation in LG (36.6%) were significantly smaller in number than those in AG (54.4%). The students with an axillary temperature below 36.0 at rising time were found to have characteristically lower level of intraday body temperature, showing the highest at around 4 o’clock in the afternoon. Also their going-to-bed time temperature did not go lower to the level of rising time. Furthermore, their heart rate was low at rising time and they were low in the intrinsic motivation for attending school at rising time.

Keywords: daily change of body temperature, life style, heart rate, intrinsic motivation for attending school

[International Journal of Sport and Health Science Vol.1 (1) 182-187]

1. Introduction

Children’s low body temperature started appearing on reports here and there in the early 1980s in Japan [Kobayashi et al. (1982); Akiyama (1983)]. Surveys of its actual status began in the 1990s [Funami et al. (1995); Sawada and Masaki (1995); Noi et al. (1997)]. As a result, although we cannot call it a disorder, the existence of children with an axillary temperature below 36.0 (hereinafter called "low temperature") and with an axillary temperature above 37.0 (hereinafter called "high temperature") has been revealed and so has the status of intraday and seasonal changes of their axillary temperature. Please note that the "low temperature" used in this study is not according to the definition in clinical medical care, but specifically means a temperature below 36.0 [Asayama (1995)]. On the other hand, Nippon College of Physical Education / Research Institute of Physical Education (1981), Masaki et al. (1996), and Abe et al. (1996; 2002) have been studying indirectly the trend of the physical change of children through the survey of "the feeling" of care providers and teachers concerning the physical state of children since 1978. When the writers took a special note of "children with a low body temperature," (1978) and "children with a normothermia below 36.0," (1990, 1995, 2000) as well as the rate of responses that say that the number of such children are "on the increase recently" in the above study, we found that the rate was 3% for elementary schools, 4% for junior high schools and 7% for high schools in the survey conducted in 1978. However, in the survey conducted in 1990, the rates jumped to 46.9%, 71.1% and 60.8% respectively for elementary, junior and sen-
ior high schools. The rates were kept at higher levels of 60.9%, 62.0% and 71.3% respectively in the survey conducted in 2000. Although these results are not actual "status" but just "feeling," they are very interesting, considering the fact that they are the feeling of care providers and teachers who are actively involved in the care and education of children day by day.

However, causes of children’s low body temperature and its potential impact have been discussed fully with only a few reports so far [Tanaka and Amari (1994); Takasaki (1997); Ishii (2002)].

Accordingly, in this study we aimed at verifying the relationship of the occurrence of low body temperature at rising time and intraday body temperature changes, rising time, going-to-bed time, exercise hours, heart rate at rising time, and intrinsic motivation for attending school at rising time.

2. Methods

2.1. Sample

In order to avoid effects of menstrual cycles, seasonal changes and physical activities on body temperature, we chose, as the subjects of this study, 452 healthy male students (164 junior high school and 288 high school students) in a junior and senior high school in Tokyo. Please note, however, that we measured the tympanic temperature, which will be discussed later in this report, of only 152 students (35 junior and 117 senior high school students).

The survey was conducted on a weekday in June 1999 and in the same month in 2001.

2.2. Measurement

The axillary temperature was taken 10 times: at rising time 7:00, 8:00, 12:00, 15:00, 16:00, 18:00, 20:00, 22:00, and at bedtime. The tympanic temperature was taken 12 times, at the above respective hours as well as at 10:00 and 14:00.

The axillary temperature was taken with a mercury thermometer for newborn, which enables measurements from 32.0 and up. As at least 10 minutes are needed to take the temperature accurately [Aihara and Iriki (1993)], we instructed the subjects to take the temperature for 10 minutes in a sitting position in rest. As it is essential to take it in an appropriate method [Aihara and Iriki (1993)], we explained the method to the subjects thoroughly before the survey.

For the measurement of the tympanic temperature, we used an infrared tympanic thermometer (First Temp Genius, Sherwood IMS, Inc.). Although the value of the tympanic temperature taken with an infrared thermometer tends to be slightly higher than that taken with a thermistor thermometer, there is a significantly close positive correlation between the two [Matsumoto et al. (1992)], which reflects the temperature of the thermoregulatory center in the brain [Benzinger (1959); Matiak et al. (1994)]. As this particular thermometer is portable, it is suitable for field measurements [Noi et al. (1998)]. However, it has a defect, i.e., changes in the measured value sometimes occur, depending upon the level of skill of the handler [Sakata et al. (1994)]. Accordingly we made the subjects practice the temperature taking fully until they got stable values for several days before the survey. Furthermore, on the day of the survey, we had them take the temperature 5 times, and we analyzed the highest value taken.

As for the measurement of heart rate at rising time, the palpation method was used, in which the pulse was taken by touching the skin over the radial artery.

2.3. Questionnaire

We surveyed rising time, going-to-bed time, exercise hours, heart rate at rising time, intrinsic motivation for attending school at rising time, using the questionnaire method. Five options were prepared concerning intrinsic motivation for attending school at rising time, namely, "5: I am motivated," "4: Yes, sort of motivated," "3: Yes and no," "2: No, I am not motivated," and "1: No, I'm not."

2.4. Statistical Analyses

The samples were divided into two groups, namely, Low group (LG) with an axillary temperature below 36.0 and Average group (AG) with an axillary temperature above 36.0 and below 37.0 at rising time. T-test (p<0.05) was conducted concerning the difference in average values of the two groups of intraday changes of axillary and tympanic temperatures, rising time, going-to-bed time, exercise hours, heart rate at rising time, intrinsic motivation for attending school at rising time.

Evaluation of responses concerning the intrinsic motivation for attending school at rising time was processed from a scale of 5 to a scale of 3 in order to integrate response items, i.e., the upper two and the lower two options were combined to form 1 response group each. χ² test (p>0.05) was conducted in the comparison of intrinsic motivation for attending school at rising time. When a significant bias was found in the number of people between the groups, contribution to the significance of the cell was examined by making
Fig. 1. Frequency histogram of axillary temperature measured for 10 minutes with a mercury thermometer at rising. Number of samples were 452 boys in secondary school. Means±SD of axillary temperature was 36.22±0.37°C.

Fig. 2. Daily changing of axillary temperature of the average and the low groups (●: Average group, ○: Low group). *: p<0.05.

3. Results

Figure 1 shows the distribution of axillary temperature at rising time of all subjects. The temperatures are distributed between 35.0 and 37.8, with 73 subjects (21.5%) with a lower temperature below 36.0, 261 subjects (76.8%) with an average temperature above 36.0 and below 37.0, and 6 subjects (1.8%) with a higher temperature over 37.0. The average temperature and standard deviation was 36.22 ± 0.37°.

Figures 2 and 3 show the changes of intraday axillary temperature and tympanic temperature of both groups. Significant difference was seen at every measuring time concerning the axillary temperature. As for the tympanic temperature, significant difference was seen at rising time, 7:00, 8:00 and 12:00. In either of the cases, the Low group showed lower values than the Average group did.

Table 1 shows the difference in the average values of the groups concerning rising time, going-to-bed time, exercise hours, heart rate at rising time, intrinsic motivation for attending school at rising time. No statistically significant difference was seen between the two groups concerning, rising time, going-to-bed time, and exercise hours. As to heart rate at rising time, however, the LG (66.6 ± 9.0 beat·min⁻¹) showed significantly lower value than the AG (70.9 ± 10.7 beat·min⁻¹), and as for the intrinsic motivation for attending school at rising time, the LG (3.0 ± 1.1 points) scored significantly lower than the AG (3.6 ± 1.2 points).

Figure 4 shows the difference in the average values between the AG and LG concerning intrinsic motivation for attending school at rising time. A significant difference was seen between the two, as 54.4% of the AG and only 36.6% of the LG were "motivated." A significant difference was seen again concerning "lack of motivation," with 15.9% of the AG and 29.6% of the LG were not motivated to attend school.

4. Discussion

Autonomic temperature regulation is controlled by somatic nervous system, autonomic nervous system, and endocrine system [Iriki (1995)]. The occurrence of children with low body temperature indicates, therefore, the change in the children’s temperature regula-
Table 1. Comparison between the average and the low groups.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Average group</th>
<th>Low group</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean±SD(n)</td>
<td>Mean±SD(n)</td>
<td></td>
</tr>
<tr>
<td>Rising time (h:m)</td>
<td>6:23a.m±0:34</td>
<td>6:30a.m±0:42</td>
<td>NS</td>
</tr>
<tr>
<td>Going-to-bed time (h:m)</td>
<td>23:23p.m±1:08</td>
<td>23:36p.m±1:03</td>
<td>NS</td>
</tr>
<tr>
<td>Exercise time in surveyed day (min)</td>
<td>49.7±6:75</td>
<td>42.2±5:34</td>
<td>NS</td>
</tr>
<tr>
<td>Heart rate at rising in surveyed day (beat·min⁻¹)</td>
<td>70.9±10:7</td>
<td>66.6±9:0</td>
<td>*</td>
</tr>
<tr>
<td>Intrinsic motivation of attending school (point)</td>
<td>3.6±1:2</td>
<td>3.0±1:1</td>
<td>*</td>
</tr>
</tbody>
</table>

*: p<0.05; NS: not significant.

tion function. However, there has been little discussion on the potential impact of children's low body temperature of below 36.0. Besides the issue of 'lowering body temperature of children' is, for the moment, happening only in Japan [Ishi (2002)], and accordingly, we cannot expect much from the result of studies overseas. Thus, it is socially significant to study the low body temperature of children.

Human body temperature undergoes intraday changes within a certain range. The intraday fluctuation of human body temperature is one of the biological indices of circadian rhythm, and it is low in the early morning, rises sharply up until noon, shows the highest value sometime in the afternoon, and then starts going down in the evening [Asayama (1995)]. This suggests that the level of human body temperature shows the level of physical activity.

In this study, we divided the subjects into AG and LG (Fig.1) based upon their axillary temperature at rising time, and compared the intraday change of the body temperature of both groups (Figs.2 and 3). The body temperature of the LG was lower than that of the AG all through the day. Also the period of time when the temperature reaches its peak was noon time for the AG, which was around 16 o'clock for the LG. Besides it was apparent that the temperature of the LG does not lower sufficiently to the level at rising time even when it was nearing bedtime.

The above suggests that as the LG is getting more and more active during the night, its biological rhythm gets disrupted, and as a result, the group tends to have lower temperature at rising time. The low levels of heart rate (Table 1) and intrinsic motivation for attending school (Table 1 and Fig.4) of the LG at rising time indicate lower level of physical activity.

However, in this study, we did not observe how the LG was getting more and more active late in the evening, as we just compared it with AG at rising time and going-to-bed time on the day of the survey, as in the preceding study [Ishii (2002)]. We need to review and improve the method of survey by including questions for distinguishing the time the subject got up and the time he started his activity as well as the time he went to bed and the time he fell asleep, and also if he woke up and/or fell asleep easily in a short period of time or not.

The level of physical activities of the LG is lower all through the day, and as the temperature peak is delayed until later in the day, it goes to bed while its temperature is not sufficiently lowered, which makes it not completely awakened in the morning, making his intrinsic motivation for attending school low. That is to say, parasympathetic nervous system of a person with lower temperature is not functioning sufficiently when he/she wakes up, as his/her sympathetic nervous system is still active, which makes him/her physically inactive.

Children who are long absentee in school and who stay in school health rooms are rapidly increasing in number, being a serious social issue in Japan. The United Nations Committee on the Rights of the Child in1998 expressed its worry over the increase of long absentee children in Japan from the viewpoint of the security of children’s rights, and made recommenda-
tion to the Japanese government to take preventive measures.

The accumulated medical biological data indicates that many of the children who are long absentee are in a state of chronic fatigue, as their amplitude of circadian core body temperature rhythm is small. The data also suggests that they are under a condition similar to jet syndrome because as their biological rhythm is disrupted, they cannot wake up in the morning, and although they are up in the evening, their energy is kept at about half the original level. The data further indicates that a healthy person's temperature reaches at its lowest sometime between 3 and 4 in the morning, while long absentee children's body temperature is lowest around 6 in the morning [Tomoda et al. (1994); Tomoda et al. (1997); Miike (2001)]. Although intraday changes of the body temperature of long absentee children in the above reports and that of the LG in this study are not identical, the phenomenon that their circadian core body temperature rhythm is shifted toward later time in the day is the same. Thus, the fact that heart rate and intrinsic motivation for attending school at rising time of the LG are lower than those of the AG, which is one of the findings of this study, should not be overlooked.

It has been reported recently that ever since the implementation of "the complete school 5-days a week system" in 2002, the intraday rhythm of children has been significantly disrupted and visitors to school health room have been on the increase on Mondays [Ozawa et al. (2002)]. We can easily guess that this will not only further the "development disorders" and "physical disorders" of children's body but also cause an increase in the number of long absentee children and children who stay in school health rooms.

In this study healthy junior and senior high school students were divided into two groups, namely, AG with an axillary temperature above 36.0 and below 37.0 at rising time and LG with an axillary temperature below 36.0 in order to compare intraday changes of their body temperature, rising time, going-to-bed time, exercise hours, heart rate at rising time and intrinsic motivation for attending school at rising time. As a result, we found out the following characteristics of children with a lower body temperature below 36:

1. Their body temperature level is kept at a lower level all day long;
2. Their body temperature reaches its peak around 4 o'clock in the afternoon;
3. Their body temperature toward the going-to-bed time does not lower to the level at rising time;
4. Their heart rate at rising time is smaller in number and their intrinsic motivation for attending school is lower.

References:
Name: Shingo Noi
Affiliation: Nippon Sport Science University
Address: 7-1-1, Fukasawa, Setagaya-ku, Tokyo, 158-8508 Japan
Main Works:
Membership in Learned Societies:
• International Union for Health Promotion and Education
• Japan Society of Physical Education, Health and Sport Sciences
• Japanese Association of School Health

Low Body Temperature in Boys


