Thermal Conditions in the Bathroom in Winter and Summer, and Physiological Responses of the Elderly during Bathing

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Abstract  Thermal conditions in the bathroom and physiological responses were examined during winter and summer. The subjects were 22 male and 20 female elderly people, between 65 and 88 years old living in 25 houses in Gunma Prefecture, Japan. Heart rate, blood pressure, skin temperature and thermal sensation were measured during bathing. Changes in thermal sensation due to bathing were assessed in the living room and dressing room on a 9-point scale. Then they were asked about the purposes of bathing and the facilities of bathroom and dressing room. The results are summarized as follows:
1. The purpose of bathing in winter was to warm up for more than 80% of the subjects.
2. In summer, all subjects felt refreshed by bathing. Eighty-five percent of the subjects took a bath every other day in both seasons.
3. Fifty-two percent of the bathrooms had no ventilating fans and 32% had no exclusive dressing rooms.
4. The average room temperature in the dressing rooms was 13-14°C in winter. Thermal sensation was 'cool', 'slightly cold' or 'cold' for more than two-thirds of the subjects when they were partially nude, and there were no heaters in most dressing rooms.
5. In winter, a marked increase of systolic blood pressure was observed in the partially nude condition. There was a significant difference between the before bathing condition and partially nude condition in winter.
6. In summer, hand and foot skin temperatures were significantly higher than those in winter at any stage of bathing. In winter, they were extremely low in partially nude condition.

In conclusion that it is necessary to improve the thermal conditions in the bathroom and dressing room, especially in winter.

Key words: Bathing, Thermal sensation, Heart rate, Blood pressure, Thermal condition in bathroom, Elderly persons
INTRODUCTION

The main purpose of bathing is to cleanse the body. In a study from 1983 to 1987, Hiraiwa et al. reported 100 deaths in the bathroom during a one-year period, and the mortality rate was higher in the elderly in Fukushima Prefecture at a hot spring area. Furthermore, Funayama et al. investigated the deaths of the elderly in the bathroom in Tokyo. They reported that the mortality in December was about 10 times more than that in July.

Most Japanese houses are not equipped with heating systems in the dressing room and bathroom. Therefore the elderly are exposed to severe cold stress before and after bathing. The impairment of many bodily functions with age makes the elderly more susceptible to environmental thermal conditions. This is one of the reasons why many deaths of the elderly in the bathroom have been reported in winter.

Most previous studies on bathing have evaluated its effects on the body in healthy young subjects or the burden due to bathing in patients with cardiovascular diseases such as myocardial infarction and hypertension. Studies on elderly subjects only estimated the burden of bathing using the cardiac rate in bedridden elderly people and did not discuss the burden in association with thermal conditions. In addition, there are few studies on the conditions in the bathroom. There is no survey concerning the effects of bathing on elderly inhabitants. Bathing and excretion are performed nearly in the nude without the influence of clothing. Therefore, elderly persons with decreased physiological functions may be readily affected by thermal conditions.

Hence, the thermal conditions in the bathroom and the physiological responses of the elderly during bathing in winter and summer were studied in this survey.

METHODS

1. Subjects

The subjects were 22 male and 20 female elderly volunteers, between 65 and 88 years old living in 25 houses, in Gunma Prefecture, Japan. Seventeen of them had cardio-vascular diseases such as hypertension, and angina. The subjects could undress and bathe without assistance. All the subjects were informed about the purpose of the experiment, and it was done in the course of daily routine of bathing. The subject bathed on the experimental day at approximately the same time as usual.

2. Procedures

Figure 1 shows the procedure and environmental conditions measured. In this survey the bathing procedure was classified into 5 stages: before bathing (in the living room), partially nude
(in the dressing room), during bathing (in the bathroom), after partially dressing (in the dressing room) and after bathing (in the living room). The subjects rested for 15 minutes prior to bathing, and they were asked about the purpose of bathing, the facilities of the bathroom, dressing room, etc. They wore their own clothes in the living room. During the measurement in the dressing room, they wore only underpants. The physiological responses measured during bathing were heart rate, blood pressure and skin temperature at 4 sites (forehead, hand, back and foot). Heart rate and blood pressure were measured at the left upper arm in a sitting position by a digital sphygmomanometer. Skin temperatures were measured using a radiation thermometer (THI -300). Mean skin temperature (Tsk) was calculated by weighting the temperatures using Burton’s equation (Burton, 1935). Changes in thermal sensation due to bathing were assessed in the living room and dressing room on a 9-point scale (1. very hot, 2. hot, 3. warm, 4. slightly warm, 5. neutral, 6. slightly cool, 7. cool, 8. cold and 9. very cold). The subjects were asked to assess the thermal sensation before bathing, while partially nude, after partially dressing and after bathing.

3. Data analysis

All values given are mean values ± SE. Each pair of group means was compared using paired t-tests or a t-test to determine the significance of the differences. The significance level was set at p<0.05.

RESULTS

1. Purpose of bathing and the facilities of the bathroom

More than 80% of the subjects took a bath to get warm, and about 60% of them were able to sleep well after taking a bath in winter. In summer, all the subjects felt refreshed due to bathing and about 32% of them took a bath to clean their bodies. More than 65% of the subjects took a bath daily in winter. About 24% of both males and females took a bath every other day. In summer, 86% of the subjects took a bath daily. The bathroom facilities were usually situated on the north side of the residence (68%), and most of them had a window, but only about half of them had ventilating fans. About 70% of them had exclusive dressing rooms, and for the rest a passageway served as the dressing room. The dressing room was heated in winter in 11.9% of the cases.

2. Thermal conditions and thermal sensation due to bathing

Table 1 shows the change in thermal sensa-

<table>
<thead>
<tr>
<th>Bathing process</th>
<th>Before bathing (Living room)</th>
<th>Partially nude (Dressing room)</th>
<th>After partially dressing (Dressing room)</th>
<th>After bathing (Living room)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal sensation</td>
<td>Winter</td>
<td>Summer</td>
<td>Winter</td>
<td>Summer</td>
</tr>
<tr>
<td>Very hot</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hot</td>
<td>0</td>
<td>1(26.2)</td>
<td>0</td>
<td>3(7.1)</td>
</tr>
<tr>
<td>Warm</td>
<td>14(33.3)</td>
<td>3(7.1)</td>
<td>0</td>
<td>9(21.4)</td>
</tr>
<tr>
<td>Slightly warm</td>
<td>13(31.0)</td>
<td>4(9.5)</td>
<td>2(4.8)</td>
<td>9(21.4)</td>
</tr>
<tr>
<td>Neutral</td>
<td>12(28.6)</td>
<td>6(14.3)</td>
<td>6(14.3)</td>
<td>12(28.6)</td>
</tr>
<tr>
<td>Slightly cool</td>
<td>0</td>
<td>11(26.2)</td>
<td>8(19.0)</td>
<td>5(11.9)</td>
</tr>
<tr>
<td>Cool</td>
<td>0</td>
<td>7(16.7)</td>
<td>7(16.7)</td>
<td>4(9.5)</td>
</tr>
<tr>
<td>Cold</td>
<td>3(7.1)</td>
<td>0</td>
<td>19(45.2)</td>
<td>0</td>
</tr>
<tr>
<td>Very cold</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Room temperature °C | 15.0±3.3 | 28.5±2.0 | 13.5±2.7 | 29.5±1.8 | 13.6±2.8 | 29.5±1.8 | 15.2±3.5 | 28.3±2.0 |

Mean skin temperature °C | 32.4±0.2 | 33.8±0.1 | 30.9±0.2 | 33.5±0.1 | 31.5±0.1 | 33.8±0.1 | 31.9±0.1 | 33.5±0.1 |

Weight of clothes Winter 1.7kg±0.07kg Summer 0.2kg±0.02kg Values are number of the subjects. (%) n=42
tion due to bathing. The mean±SE temperature of the living room in winter was maintained at about 15°C±3.5°C by using a gas or fan heater. On the other hand, the temperature in the dressing room was from 6°C to 19°C with an average of 13.5°C. In the living room, the subjects did not complain about the cold mainly because they were using heaters and foot warmers and were dressed warmly. The mean±SE weight of clothes in winter was 1.7kg±0.07kg. In winter, the thermal sensation in 70% of the partially nude persons in the dressing rooms was 'cool', 'slightly cold' or 'cold'. In this situation, a heater was used by only 9.1%. The average temperature of the living room in summer was about 28°C and that of the dressing room was about 29.5°C. The mean±SE weight of clothes in summer was 0.2kg±0.02kg. In summer, the thermal sensations were from 'cool' to 'very hot' in the living room and dressing room.

3. Physiological responses to bathing

Figure 2 shows the changes in heart rate due to bathing. The mean±SE temperature of the water temperature in winter was 40.8°C±0.32°C. In summer, it was 40.1°C±0.22°C, which did not differ significantly from that in winter. The average heart rate was from 72 to 85 beats/minute in winter, and from 72 to 83 beats/minute in summer. The heart rate increased while undressing and reached a maximum value in the partially-dressed condition in both seasons. After bathing, the heart rate decreased gradually. No significant differences in heart rate were found between winter and summer at any stage of bathing. Significant differences were found between the partially nude condition and during bathing condition, and between the after partially dressed condition and the after bathing condition in both seasons.

Figure 3 shows the changes in systolic blood pressure due to bathing. In winter, a marked increase of systolic blood pressure was observed in the partially nude condition. The systolic blood pressure before bathing was 139 mmHg, and 154 mmHg in the partially nude condition. It decreased suddenly during bathing and reached a minimum when the subject was partially dressed. Thereafter it increased slightly after bathing. Changes in systolic blood pressure due to bathing in summer differed from those in winter. It increased gradually, reaching a maximum value during the bathing conditions and thereafter decreased gradually. Significant differences in systolic blood pressure were found between winter and summer in before bathing, partially nude and after bathing conditions.

The pattern of change in diastolic blood pressure due to bathing in both seasons was similar to that of the systolic blood pressure in winter. No significant differences in systolic or diastolic blood pressure during bathing or after partially

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Fig. 2 Changes in heart rate caused by bathing. Values are means and standard errors.

Fig. 3 Changes in systolic blood pressure caused by bathing. Values are means and standard errors.
dressed were found between winter and summer. However, in winter, values were significantly higher before bathing in the partially nude condition and after bathing than in summer.

Figure 4 shows the comparison of systolic blood pressure caused by bathing between the normal elderly and the elderly with cardiovascular diseases (CVD). In both seasons, the blood pressure was higher in the subjects with CVD than in those without CVD by 8–19 mmHg during the entire course of bathing. However, in winter, both groups showed similar profiles except for the blood pressure in the partially dressed condition. Both groups showed a marked increase in blood pressure in the partially nude condition in winter. In particular, a systolic blood pressure of more than 160 mmHg on the average, was found in the group with cardiovascular disease.

4. Physiological and subjective responses due to bathing

Figure 5 shows the relationship between the mean skin temperature and the thermal sensation in the dressing room. In winter, a significant correlation was observed between the mean skin temperature and thermal sensation in the partially nude condition (r=-0.385, p<0.05). Most subjects felt cold at a mean skin temperature of 30°C or less. On the other hand, there were no significant correlations between the mean skin temperature and thermal sensation in the partially nude condition in the after partially dressed condition in winter or in the partially nude and after partially dressed conditions in summer.

Figure 6 shows the relationship between the mean skin temperature and systolic blood pressure in the dressing room. Although negative correlations were observed between the mean skin temperature and systolic blood pressure in the partially nude condition in both seasons, they were not significant (r=-0.245 in winter and 0.226 in summer).

Figure 7 shows the relationship between the
increase in systolic blood pressure and thermal sensation in winter. The increase in systolic blood pressure was presented as the elevation in the partially nude condition from the value before bathing condition. A pressure increase of 10 mmHg or more was more frequently observed in patients who felt cool or cold. However, there were several cases (11.9%) with an increase of 10 mmHg who did not feel "cool" or "cold".

**DISCUSSION**

Bathing may cause stress to the body; it increases the heart rate in patients who have a cardiovascular disease such as ischemic heart disease and hypertension. Therefore, studies have been widely carried out on the effects of bathing or shower bathing on healthy students or adults and on patients with cardiovascular disease\(^3\text{--}^6\).

On the other hand, the elderly have been merely surveyed about the load on the body when they take a bath with full support in a nursing home\(^7\). Those examinations were carried out in well-equipped thermal conditions. The thermal conditions adopted were moderate conditions (25°C). The physiological strain due to bathing at home where the thermal conditions fluctuate remains unknown.

Tanaka et al.\(^8\) surveyed room temperature in a total of 664 bathrooms and dressing rooms. In the present study, we examined the thermal conditions in the bathroom and the physiological responses of the elderly during bathing in winter and summer. The facilities of the bathroom and dressing room were insufficient and the elderly were exposed to cold stress during bathing in winter. Tanaka et al.\(^8\) pointed out that thermal conditions in the bathroom and dressing room were not sufficient and these rooms should be heated.

In the living rooms, elderly persons did not complain about the cold mainly because they were heated with a gas or oil heater and the subjects were dressed warmly. The average mean skin temperature was 32.8°C in the before bathing condition. The average air temperature of the dressing room in winter was 13.0°C. Although 70% of the partially nude persons in the dressing rooms felt 'cool' or 'slightly cold' or 'cold', a heater was used only in 9.1% of the cases (Table 1). In winter, mean skin temperatures
were extremely low in the partially nude condition. This may have been caused by the contraction of the blood vessels, especially in peripheral areas to suppress surface heat loss. This is a defense response of the body to maintain the temperature in important organs even when the temperature in the peripheral areas decreases.9)

In the partially nude condition, fewer persons complained of being cold after bathing and accounted for only 9.1% of the number before bathing in the same thermal condition. This may be due to the warming effect of bathing. The skin temperature increased by a mean of 1.8°C due to bathing, showing warming effects. In winter, more subjects felt cold with a lower foot temperature in the partially nude condition. Young men and women complain of the cold under cold conditions (20°C)10). By contrast, about 30% of the subjects in this study did not complain about cold under cold conditions. This suggests that the cutaneous sensation and the discrimination of temperature decreases with aging.11–13)

The heart rate increased steadily due to bathing, reaching a maximum in the partially dressed condition in both seasons (Fig. 2). After bathing it decreased gradually. These findings coincided with the previous reports by Shintani et al.9), Shimura et al.5) and Nojiri et al.14). They examined the physiological responses due to bathing in young people, during actions such as movement, changing clothes, and washing the body. Kidoue et al.15), reported that energy consumption during dressing after bathing was higher than that before bathing.

One of the most interesting findings of this study was a marked increase of systolic blood pressure observed in the partially nude condition in winter (Fig. 3). In previous investigations, the changes in blood pressure due to bathing varied. Shintani et al.9) reported that while the systolic blood pressure of subjects immersed in warm water (40°C) was not different from that of the control state, it was consistently higher when they were washing themselves outside the bathtub. Shimura et al.5) found an increase in systolic blood pressure and a decrease in diastolic blood pressure due to bathing (42°C) in summer. Kiuchi et al.16) reported that as the water temperature increased, the systolic blood pressure increased immediately following the bath. However, the examinations in the dressing room were carried out under adjusted conditions without cold stimulation, and no marked increase of systolic blood pressure was observed in the partially nude condition. The systolic blood pressure decreased suddenly during bathing, reached a minimum in the partially dressed condition and thereafter showed a tendency to increase after bathing. The marked increase of systolic blood pressure in the partially nude condition in winter might have been caused by work load and/or stimulation from the cold. The work load was similar in both seasons. Therefore, the greater increase in systolic blood pressure in winter must have been caused by the cold environment in the partially nude condition. In particular, as shown in Fig. 4, a great increase in systolic blood pressure in the elderly with cardiovascular disease was found. Therefore, to clarify the cause of the increase in the systolic pressure, its associations with mean skin temperature (Fig. 6) and thermal sensation (Fig. 7) in the partially nude condition were evaluated. However, these factors were not correlated with the increase in the systolic blood pressure. These results may be associated with inconsistent undressing conditions in the places investigated and complicated interaction of various factors such as body fatness17), a degree of adaptation to cold18) and the nutritional of the subjects19).

As shown in Fig. 7, there were several subjects (11.9%) who had an increase in systolic blood pressure without the feeling of coldness in this study. Tochihara et al.11) measured the physiological responses and thermal sensations of the elderly in cold and hot environments and reported a high risk of decrease in deep body temperature and a rapid increase in blood pressure in the
elderly, without any sensation of cold. However, the most appropriate temperature for elderly people in winter is 23°C in the living and dining rooms, and 25°C for the dressing room. In this study, the average temperatures of the living room and the dressing room were 15°C and 13°C, respectively. It is necessary to improve the environment of the bathroom and the dressing room in order to bathe safely with minimum work load on the living body. Especially in winter, a marked increase in blood pressure and a decline in skin temperature were observed in the partially nude condition. The poor heating conditions of the dressing rooms may be a significant hazard. Our results indicate the necessity to improve the heating conditions of the dressing room in Japan. Further studies of the effects of thermal conditions in the bathroom and dressing room will be carried out under laboratory conditions.

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(Received Nov. 16, 1993/ Accepted Jan. 12, 1995)