Influence of the Thermal Environment of a Bathroom after Renovation on Blood Pressure of Residents

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Abstract.
Many Japanese people are dissatisfied with the coldness of dressing rooms and bathrooms. It is well known that accidents due to changes in blood pressure during bathing may lead to casualties, particularly in elderly people. However, measurements of blood pressure changes along with evaluation of the thermal environment in residential buildings are very limited. This study aimed to survey the influence that the thermal renovation of the dressing rooms and bathrooms has on the health of elderly residents during winter in residential buildings in Hokkaido, a cold northern region in Japan.

Three detached residences built before the 1990s, whose residents were over 60 years of age, were renovated. Bath units were replaced, or additional thermal insulation was added to the openings and floor of the dressing rooms and bathrooms. Before and after the renovation, the thermal environment around the bathroom was evaluated and the blood pressure of residents during bathing was measured. From undressing in the dressing room until dressing after bathing, blood pressure was measured sequentially by the residents themselves using a handy-type hemadynamometer.

After renovation, the increase in the highest systolic blood pressure during undressing time and the range of the blood pressure change during the whole bathing process were lower than those before renovation. Systolic blood pressure decreased with the increase in dressing room temperature. Correlation analysis showed that systolic blood pressure decreased up to 20 mmHg when the dressing room temperature increased by 10°C.

Keywords: Bathing, Renovation, Thermal Environment, Blood Pressure, Elderly.

1 Introduction

Bathing is very effective in relieving fatigue and is thus one of the most important daily actions for Japanese people. However, the number of people, especially elderly people,

whose deaths result from an accident in the bathroom is large. Most of them die due to heart and blood vessel diseases exacerbated by a sudden change in blood pressure due to changes in the thermal environment around the human body during bathing [1] and dizziness caused by postural changes [2]. Several experiments examining body temperature, blood pressure, and pulse during bathing showed that elderly people experience larger changes in blood pressure and a slower cardiovascular response than young people, and the temperature of hot water in the bath and dressing rooms have a significant influence on the change in body temperature and blood pressure during bathing [3], [4], [5]. Kajii [6] carried out experiments to examine the relationship between bathing posture and blood flow and changes in body temperature. These results indicated that an improvement of the bathing environment may be effective to achieve safer and more comfortable bathing and that the prediction of physiological response during bathing is essential to design a suitable environment in bathrooms and dressing rooms.

However, research on actual situations that include blood pressure data has been very limited, probably because continuous and detailed measurement of blood pressure is difficult, particularly for elderly people. This study investigated the influence that an improvement of the indoor thermal environment due to thermal renovation of dressing rooms and bathrooms has on the safety of bathing in Taikicho, Hokkaido, where winter is very severe. An inquiry survey on basic information regarding heating and living environment was conducted and then blood pressure during bathing was measured along with evaluation of the thermal environment in dressing rooms and bathrooms before and after the renovation.

2 Outline of survey

2.1 Surveyed residences and subjects

Three detached houses in Taikicho, a town in northern Japan, built before 1990, were surveyed. The residents of these houses are couples (a husband and a wife) over 60 years of age. Table 1 lists some attributes of the residents such as age and treated disease.

Table 1. Attributes of the residents.

Residence	Resident	Age	Occupation	Bedtime	Wake-up	Treated disease	Renovation
House A	Husband	62	−	22:00	6:00	Diabetes	from 13 to 21
	Wife	62	−	22:00	6:00	High blood pressure	Jan., 2015
House B	Husband	85	−	22:00	6:00	High blood pressure	from 18 to 28
	Wife	83	−	23:00	7:00	High blood pressure	Jan., 2015
House C	Husband	64	Office work	22:00	6:00	High blood pressure Nasal catarrh	from 8 to 15
	Wife	60	−	22:00	6:00	Sensitivity to cold	Jan., 2015

The survey was conducted from April 2014 to March 2015. In the first half of the period, a preliminary survey was conducted and detailed designs of the renovations

were produced. The renovation was done in January 2015. Before and after the renovation, the thermal environment was evaluated and blood pressure measured.

2.2 Renovation of residences

(1) House A. The old bath unit with poor thermal insulation and an inefficient ventilator for dehumidification was replaced by a more efficient one (Figure 1). The wall and floor of the bathroom were also insulated (Figure 2). Because the door of the dressing room leading to the outside was poorly insulated, causing the dressing room to be cold and condensation to accumulate on the door, it was insulated.

Figure 1. New bath unit

Figure 2. Wall insulation (left: before renovation) and undersurface of the floor (right: after renovation)

(2) House B. The tiled bathtub was replaced with a bath module with thermal insulation to prevent a drop in temperature of the hot water (Figures 3 and 4). The tiled bathroom was also insulated to increase the bathroom temperature (Figures 3 and 4). The service door leading to the corridor adjacent to the dressing room was also insulated.

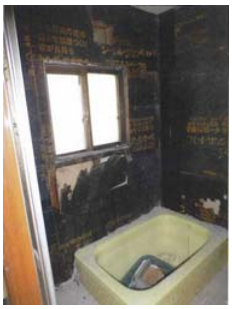

Figure 3. Removal of inner finishing tile

Figure 4. Setting of new bathtub

(3) House C. The undersurface of the floor not only of the dressing room and bathroom but also of the kitchen and entrance areas was insulated to slightly warm the

whole house (Figures 5 and 6). In addition to the insulation of the floor, the external wall of the space connecting the car garage and the entrance hall was insulated and made airtight.

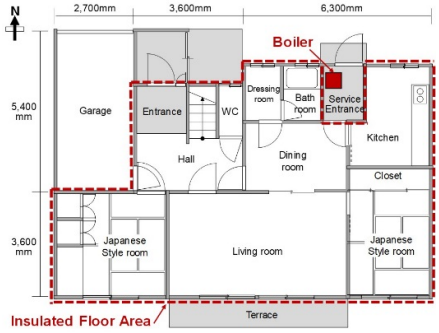

Figure 5. Plan of first floor and insulated area.

Figure 6. Insulation of undersurface of floor.

2.3 Measurement of blood pressure

(1) Outline of measurement. Blood pressure, along with the temperature and humidity of the dressing rooms and bathrooms, was measured sequentially in a clothed condition in a dressing room before bathing and in a clothed condition again after bathing to delineate the blood pressure changes under actual bathing conditions and to clarify the relationship between the indoor thermal environment and blood pressure. The results were expected to clarify the influence, via the change in thermal environment, of the insulation renovations of the dressing room, bathroom, and bathtub on the health (blood pressure) of the residents. Because the residents of the surveyed houses were aged from 60 to 80 years, the influence of the thermal environment on their blood pressure during bathing was expected to be not insignificant.

(2) Survey and measurement methods. First, the residents were asked about their usual actions when bathing. Subsequently, the timing of blood pressure measurement appropriate for each resident was determined and a questionnaire sheet was designed. In addition to entries of the measured values of blood pressure, entries of other factors such as heating of the bathroom, reheating of hot water, alcohol drinking before bathing, and set point temperature of hot water were included in the questionnaire sheet. The subjects were also asked to register their posture (standing or sitting) and whether clothed by him/herself, when measuring blood pressure. The measurements were made at least twice (2 days), before and after the renovation by the residents (subjects) themselves.

(3) Measurement procedures. The measurements were carried out in the following order: ① in the living room, ② in the dressing room in a clothed condition, ③ in the dressing room in an unclothed condition, ④ just after moving to the bathroom, ⑤ before getting into the bathtub after washing their body or hair, ⑥ just after getting into the bathtub, ⑦ just before getting out of the bathtub, ⑧ repeat processes ⑤ to ⑦ if getting into the bathtub more than once, ⑨ just after getting out of the bathroom, ⑩ repeat processes ③, ②, ① after moving to the dressing room.

Blood pressure was measured sequentially using a handy-type hemadynamometer (OMRON HEM-6310F) by the residents themselves. Each blood pressure measurement took approximately 40 seconds, and the data were stored in the hemadynamometer. After bathing, the residents were asked to register the measuring time, systolic and diastolic blood pressure, and pulse rate into the questionnaire sheet.

3 Survey and measurement results

3.1 House A

Figures 7 and 8 show the systolic and diastolic blood pressure and pulse rate of the husband and wife in House A, along with the room temperature of the living room, dressing room, and bathroom. The orange shaded area indicates the period during which the resident was in a bathtub.

Husband (Figure 7). Before the renovation (January 10, 2015), systolic blood pressure of the husband in House A increased from 165 to 175 mmHg in the dressing room, and decreased from 165 to 125 mmHg in the bathtub. It increased again to 160 mmHg in the dressing room after bathing. The dressing room temperature was almost constant at 20°C through the whole bathing process. After the renovation (January 30, 2015), the systolic pressure increased only up to 145 mmHg in the dressing room, and decreased to 80 mmHg in the bathtub. Through the entire bathing process, systolic blood pressure decreased from 50 to 45 mmHg. The dressing room temperature was between 21.5°C and 22°C, higher than it was on January 10.

Wife (Figure 8). Before the renovation, the systolic blood pressure of the wife in House A increased up to 140 mmHg in the dressing room, and the total change in the systolic pressure during the whole bathing process was 60 mmHg. After the renovation, systolic pressure increased only up to 120 mmHg, and the total change was less than 30 mmHg. The dressing room temperature increased from approximately 21°C before the renovation to 22.5°C after the renovation.

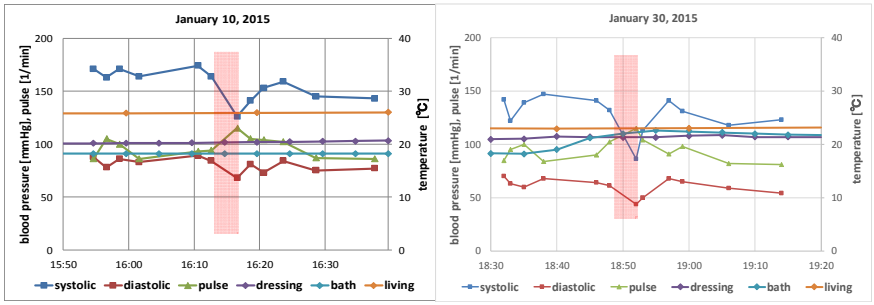

Figure 7. Systolic and diastolic blood pressure of House A husband (left: before renovation; right: after renovation)

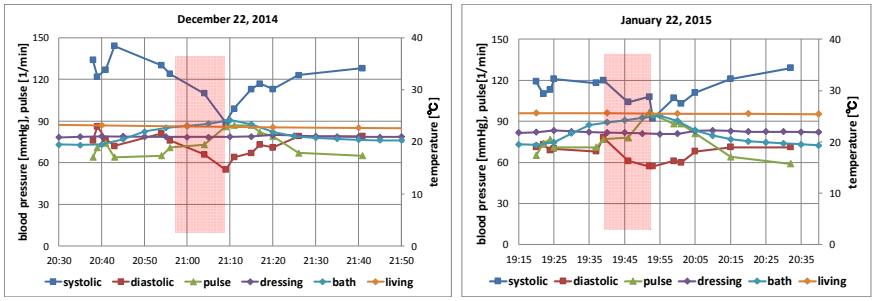

Figure 8. Systolic and diastolic blood pressure of House A wife (left: before renovation; right: after renovation)

3.2 House B

Figures 9 and 10 show the systolic and diastolic blood pressure of the husband and wife in House B during bathing, respectively, along with the temperatures of the living room, dressing room, and bathroom. The set point of the hot water temperature was between 40°C and 42°C, and neither the husband nor the wife reheated the hot water.

Husband (Figure 9). Before renovation (December 19, 2014), the systolic blood pressure of the husband increased from 130 to 180 mmHg in the dressing room and decreased to 100 mmHg in the bathtub. But after the renovation (January 29, 2015), it increased only up to 150 mmHg in the dressing room. Through the whole bathing process, systolic blood pressure decreased from 80 to 50 mmHg. Before the renovation, the dressing room temperature before bathing was approximately 15°C whereas it was 16°C after bathing, and these values increased to 16°C and approximately 18°C, respectively, after the renovation.

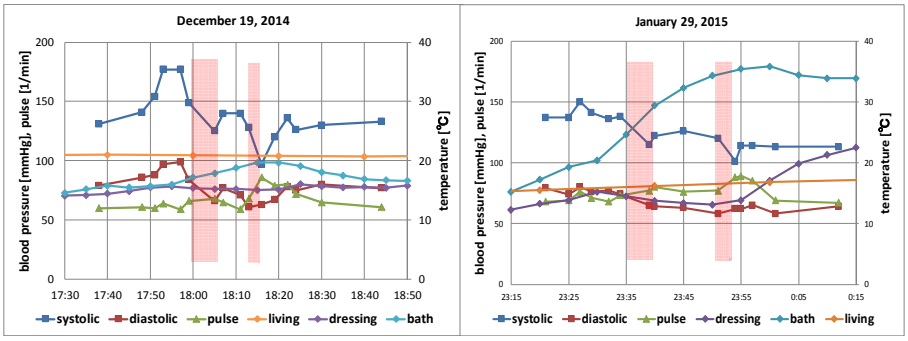

Figure 9. Systolic and diastolic blood pressure of House B husband (left: before renovation; right: after renovation)

Wife (Figure 10). The systolic blood pressure of the wife normally fluctuated between 150 and 200 mmHg even aside from bathing, indicating that she had high blood pressure as an illness. Before the renovation, her systolic blood pressure reached up to 230 mmHg in the dressing room (January 10, 2015), and the total change in the systolic pressure during the bathing process was 80 mmHg. However, the systolic pressure increased only up to 200 mmHg, and the total change was less than 25 mmHg after the renovation (February 4, 2015). The temperature in the bathroom was between 16°C and 20°C before renovation, but it increased to between 20°C and 36°C after the renovation due to the use of the heating system of the unit-bath.

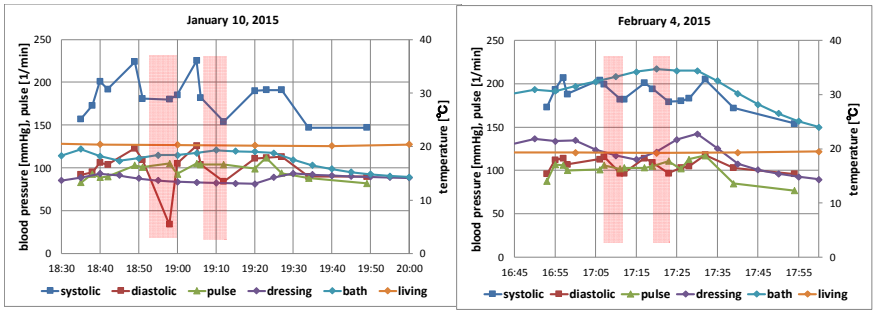

Figure 10. Systolic and diastolic blood pressure of House B wife (left: before renovation; right: after renovation)

3.3 House C

Husband (Figure 11). Before the renovation, the systolic blood pressure of the husband in House C increased from 125 to 140 mmHg in the dressing room, and after the renovation, it increased from 110 to 140 mmHg, and decreased to 90 mmHg in the bathtub, much lower than before the renovation. Through the whole bathing process, systolic blood pressure increased from 30 to 50 mmHg. The dressing room temperature

changed from approximately 12.5°C before the renovation to 13.5°C after the renovation, slightly higher. Therefore, in this case, both the systolic blood pressure and the total pressure change increased after the renovation, although the dressing room temperature increased.

Wife (Figure 12). Before the renovation (January 6, 2015), the systolic blood pressure of the wife in House C was approximately 130 mmHg in the dressing room and decreased to 100 mmHg in the bathtub. The total change in the systolic pressure was 30 mmHg. After the renovation (January 26, 2015), the total change in the systolic pressure slightly decreased to 25 mmHg, although the dressing room temperature became higher from 13°C to 15°C after the renovation.

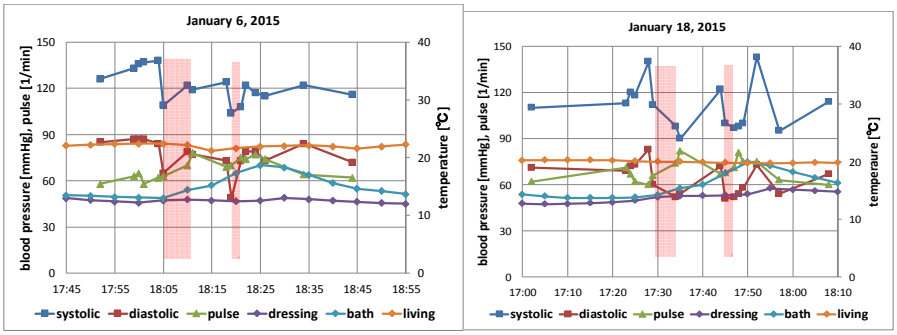

Figure 11. Systolic and diastolic blood pressure of House C husband (left: before renovation; right: after renovation)

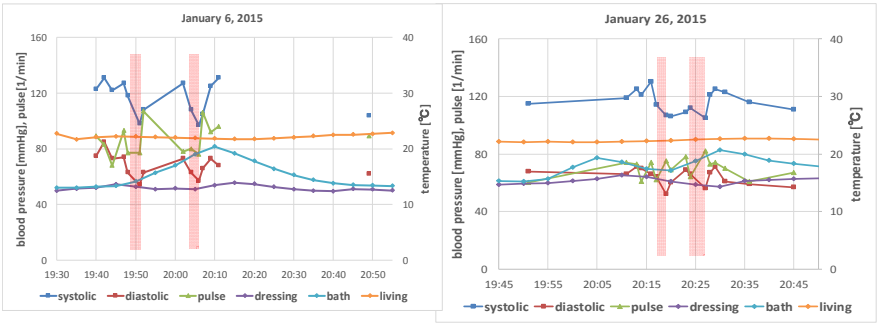

Figure 12. Systolic and diastolic blood pressure of House C wife (left: before renovation; right: after renovation)

Because the temperatures of the dressing room and bathroom depend on the outdoor temperature and other factors, these factors should be taken into consideration when evaluating the effect of the renovation.

3.4 Relationship between dressing room temperature and systolic blood pressure

Although most of the obtained results so far showed a tendency for systolic blood pressure to become lower after the renovation, and the total change throughout the whole bathing process decreased, the temperature increase in the dressing room and bathroom due to the renovation differed between houses and on each day probably due to the outdoor weather conditions. Therefore, the relationship between dressing room temperature and systolic blood pressure was examined. The dressing room temperatures both before and after bathing were examined.

Figures 13 shows the relationship between the dressing room temperature and the systolic blood pressure of each resident. The dressing room temperatures before and after bathing are distinguished by different symbols. The straight lines in the figure are the correlation curves.

In every case, systolic pressure is negatively correlated with dressing room temperature. Furthermore, the systolic blood pressure after bathing was lower than that before bathing, and the (negative) gradient of the correlation line is steeper after bathing

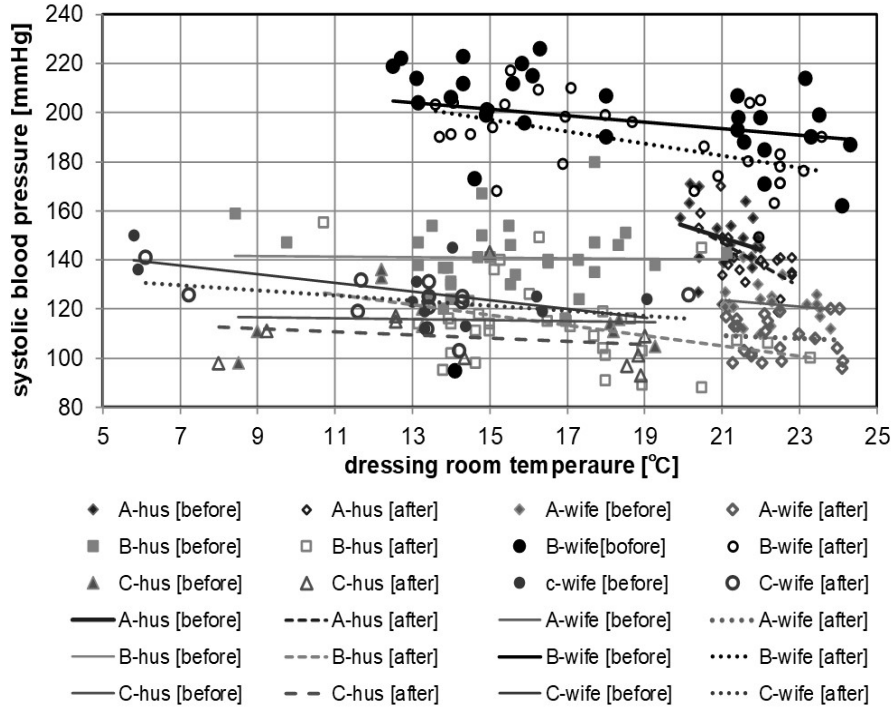

Figure 13. Relationship between dressing room temperature and systolic blood pressure before and after bathing of all residents

in many residents. This indicates that the systolic pressure decease with the increase in dressing room temperature is larger after bathing than before bathing. This might be related to the dilatation of the skin blood vessel caused by heat exchange with the hot water in the bathtub.

The gradient of the correlation line of each resident is relatively similar, showing that systolic blood pressure decreases by 0 to 20 mmHg with each 10°C increase in the dressing room temperature.

4 Conclusion

In this study, the influence that the thermal renovation of dressing rooms and bathrooms has on the health of elderly residents during winter was surveyed in residential buildings in Hokkaido, a cold northern region in Japan.

Bath units were replaced or additional thermal insulation was added to the openings and floor of the dressing room and bathrooms. Before and after the renovation, the thermal environment around the bathroom and blood pressure of residents during bathing were measured, along with an inquiry survey on the heating system of the residence and the lifestyle of the participants.

After the renovation, it was found that there was a tendency for the increase in the highest systolic blood pressure during undressing time and the range of the blood pressure change during the whole bathing process to be lower than those before the renovation. It was clarified that systolic blood pressure decreased with increased dressing room temperature. The correlation analysis showed that systolic blood pressure decreased up to 20 mmHg when the dressing room temperature increased by 10°C.

The number of the subjects is only six in this preliminary study, and more research is needed to draw firm conclusions.

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