

# Hemodynamic Response during Japanese-Style Bathing in Elderly Disabled Subjects

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## Abstract

**Aims:** Bathing in deep, Japanese-style bathtubs is associated with high rates of sudden death in the elderly in Japan. The predominant causes of death in such cases are cardiovascular events and drowning. Blood pressure changes induced by water pressure and high temperature during bathing may be an important cause of these accidents. Therefore, we investigated the changes in blood pressure, heart rate, and oxygen saturation (SpO<sub>2</sub>) before and after bathing in elderly Japanese individuals. **Methods:** Forty-eight elderly (average age, 86.4 ± 7.5 years) persons were enrolled in this study. **Results:** Changes in systolic blood pressure after bathing correlated negatively with baseline blood pressure before bathing, and participants with baseline systolic blood pressures of <125 mmHg experienced a greater elevation in blood pressure while bathing. Pulse rate was significantly increased after bathing, and the change in pulse rate correlated negatively with the baseline values. SpO<sub>2</sub> did not differ significantly during bathing, but changes in SpO<sub>2</sub> correlated negatively with baseline values. Lean participants showed a more marked elevation of SpO<sub>2</sub>, and those with hypertension showed reduced SpO<sub>2</sub>. **Conclusion:** These data suggest that the disabled elderly with low blood pressure experience trends in cardiovascular response during bathing which differ from those of young persons.

## Keywords

Elderly, Blood Pressure, Heart Rate, SpO<sub>2</sub>, Bathing, Japanese-Style Bathtub

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## 1. Introduction

The incidence of drowning at home in the elderly over age of 65 years has been reported as 17.2/100,000 per year in the Japanese population [1]. Accidents during bathing occur at a rate of 11.0/100,000 per year, and the rate is especially high in the elderly [2] [3]. In most cases, postmortem evaluation attributed disease-related deaths during bathing to cardiovascular disease (70.5%), including ischemic heart disease, cerebral stroke (23.2%), and accidental deaths due to drowning (81.0%) [2]. The incidence of sudden death during bathing is extremely high in Japanese-style baths compared with that in Finnish-style saunas (2/100,000 persons per year) [4]. Japanese-style baths are deeper, and the temperature is higher, which makes bathing in Japan very different from spending time in saunas and baths in other countries [5]. Most studies concerned with blood pressure changes in a bathtub have been carried out with young volunteers and healthy elderly participants [6]-[10]; however, mechanical and thermal factors in the bathtub might have a greater effect on the disabled elderly than on the young and healthy. To provide data that can assist in improving care of the elderly in nursing homes, we determined the changes in hemodynamics during bathing, and we also examined the levels of SpO<sub>2</sub> as a measure of the changes in oxygenation induced by such hemodynamic changes during bathing.

## 2. Participants and Methods

### 2.1. Subjects and Protocol

This study was carried out according to Helsinki Declaration and with permission of the Ethics Committee of Wakayama Medical University (Permission No. 507). Elderly individuals ( $n = 48$ ; 9 men, 39 women; average age,  $86.4 \pm 7.5$  years; 33 living in nursing home, 15 visiting nursing home) were enrolled in this study after giving informed consent. Most of the participants in the nursing home needed care because of their advanced age but did not suffer from a severe disease or need hospitalization. Forty-eight participants had some underlying disease, and 37 took medications. Of the participants with underlying medical conditions, 32 had hypertension, 10 had stroke, 5 had diabetes mellitus, 5 had cardiac disease, 2 had dementia, and 3 had other diseases (when participants had diseases more than two, number of diseases was calculated repeatedly). Twenty-seven of the participants took antihypertensive drugs (calcium antagonist: 20; angiotensin II receptor blockade: 5; diuretics: 8; beta blockade: 1; unknown antihypertensive drugs: 5); and 5 took unknown drugs (when participants took drugs more than two, number of drugs was calculated repeatedly). Situation of daily life in subjects was shown in **Table 1**. Average values of height, body weight, and body mass index (BMI) were  $145.4 \pm 7.4$  cm,  $47.3 \pm 9.1$  kg, and  $22.3 \pm 3.7$ , respectively. Room temperature in the bath room of the nursing home was 29°C, and room humidity was 72%. The temperature of the hot water in the bath was 40°C - 41°C. All participants disrobed, soaked for 5 min, and then washed their bodies themselves with the assistance of one or two caregivers. Special wheelchairs that can be used in the bathtub were used for participants with gait disturbances. We measured blood pressure, pulse rate, and SpO<sub>2</sub> with an aneroid manometer and pulse oxymeter (SAT-2100, NIHON KODEN Co. Ltd., Tokyo, Japan) once before bathing, once just after bathing, and once after donning their clothing. Blood pressure, pulse rate, and SpO<sub>2</sub> measurements were obtained after the participants had rested in a sitting position

**Table 1.** Situation of daily life.

Indoor movement (number)	
Wheelchair by assistance	9
Wheelchair by oneself	9
Walk using the stick	7
Walk without assist	17
Bathing (number)	
Normal	30
At sitting position on the bath-chair	17
At recumbent position on stretcher	1
Eating (number)	
By oneself	48

for a few min. The first blood pressure measurement was taken before disrobing, the second was taken after the caregiver dried the participant, and the last measurement was carried out after the participant was clothed. To shorten the measurement time, each measurement was performed only once, but we compared each value to normal blood pressure levels to avoid inaccuracy. The purpose of the final measurement was to detect abnormalities in blood pressure or pulse rate variation, and these data were not used in the present analysis.

## 2.2. Statistical Analysis

Data are expressed as mean  $\pm$  standard deviation (mean  $\pm$  SD) values. Two parameters before and after bathing were analyzed by the paired *t*-test. Correlation between two values was evaluated by univariate regression analysis. IBM SPSS Statistics 19 was used for analysis. Differences were considered significant at  $P < 0.05$ .

## 3. Results

### 3.1. Blood Pressure

The average values of systolic/diastolic blood pressure before and immediately after bathing were  $123.9 \pm 18.4/61.4 \pm 11.8$  mmHg and  $129.0 \pm 21.6/64.0 \pm 12.0$  mmHg, respectively (**Table 2**); and differences were not significant. As shown in **Figure 1**, the average systolic blood pressure before bathing was significantly correlated with that after bathing ( $r = 0.553$ ,  $P < 0.001$ ). The average diastolic blood pressure before bathing showed a significant correlation with that after bathing ( $r = 0.592$ ,  $P < 0.001$ ). Participants with baseline systolic blood pressure of  $<125$  mmHg before bathing showed the highest elevation of blood pressure after bathing, and there was a negative correlation between the change in systolic and diastolic blood pressure after bathing and baseline values ( $r = 0.342$ ,  $P = 0.017$  and  $r = 0.439$ ,  $P = 0.002$ , respectively) (**Figure 2**).

### 3.2. Pulse Rate

Pulse rates before and immediately after bathing were  $73.5 \pm 10.6/\text{min}$  and  $77.5 \pm 10.4/\text{min}$ , respectively (**Table 1**). The pulse rate was significantly increased by bathing ( $P = 0.031$ ). The change in pulse rate during bathing correlated negatively with the baseline value ( $r = 0.427$ ,  $P = 0.0024$ ) (**Figure 3**).

### 3.3. SpO<sub>2</sub>

The values of SpO<sub>2</sub> showed no difference before and after bathing, as shown in **Table 1**. There was a negative correlation between the change in SpO<sub>2</sub> during bathing and the baseline value ( $r = 0.559$ ,  $P < 0.0001$ ) (**Figure 3**).

### 3.4. Body Mass Index (BMI)

Because obesity is an important factor that increases hemodynamic changes after exercise, we examined the relationship between BMI and blood pressure changes. Regression analysis was performed for BMI and the changes induced by bathing in systolic and diastolic blood pressure, pulse rate, and SpO<sub>2</sub>. There were no significant relationships between these parameters. Lean participants with a BMI of 13.6 showed a 9% elevation in SpO<sub>2</sub> after bathing (**Figure 4**). Two participants with hypertension (150/60 mmHg and 140/60 mmHg) showed an 8% reduction in SpO<sub>2</sub> after bathing.

## 4. Discussion

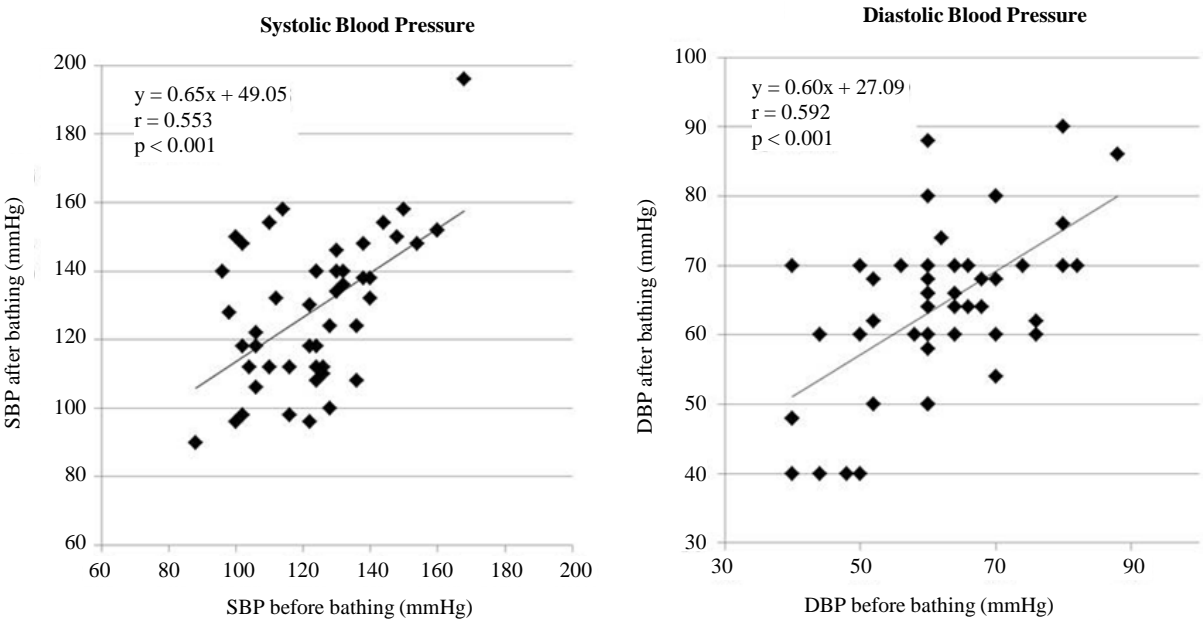
Accidents in the bath occur often in Japan, especially in the elderly; and these accidents specifically involve deep, Japanese-style bathtubs. Recently, bathing services have been provided in nursing homes, and the opportunity to bathe has increased [11]. Therefore, knowledge of hemodynamic changes during bathing is important to prevent sudden death in the bathtub. Chishaki *et al.* [6] have reported that systolic blood pressure showed no change during bathing and diastolic blood pressure was reduced during bathing in the elderly.

In contrast, the pulse rate was increased during bathing and decreased afterwards. Kawamoto *et al.* [12] reported that blood pressure and heart rate were transiently elevated during bathing in the bedridden elderly. Miyao *et al.* [13] showed that systolic and diastolic blood pressure and heart rate were reduced during bathing in the elderly. Nagasawa *et al.* [14] showed that blood pressure in young individuals decreased during bathing;

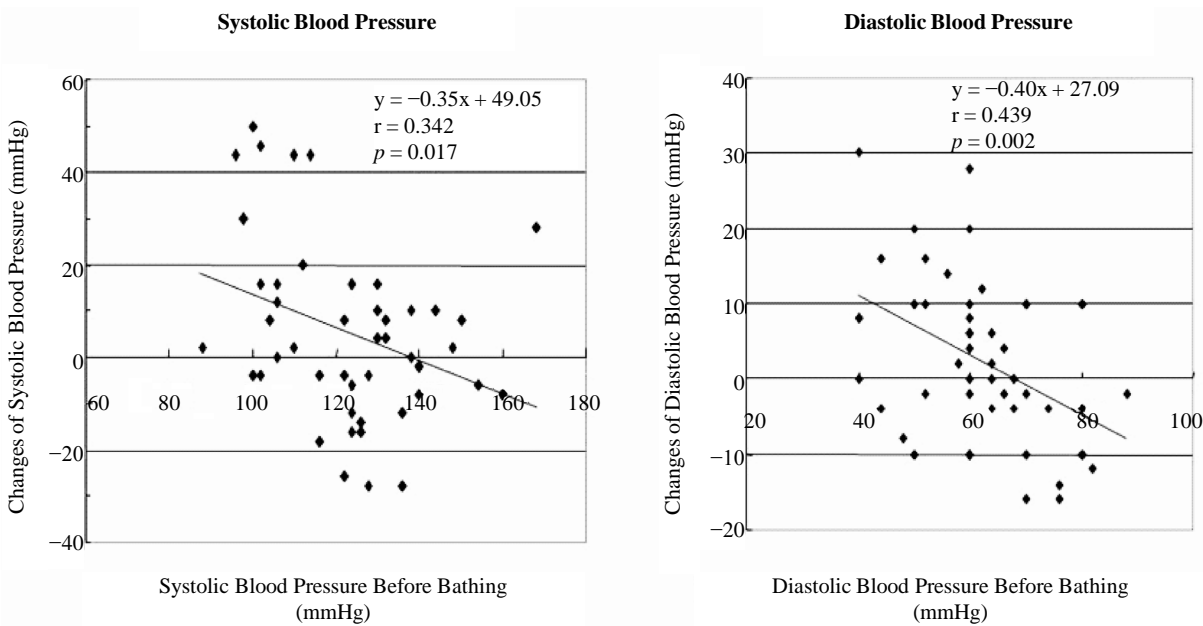
**Table 2.** Blood pressure, pulse.

	Before bathing	Just after bathing
Systolic blood pressure (mmHg)	123.9 ± 18.4	129.0 ± 21.5
Diastolic blood pressure (mmHg)	61.4 ± 11.8	64.0 ± 12.0
Pulse rate (/min)	73.3 ± 10.6	77.5 ± 10.4
SpO <sub>2</sub> (%)	94.8 ± 2.5	94.6 ± 2.5

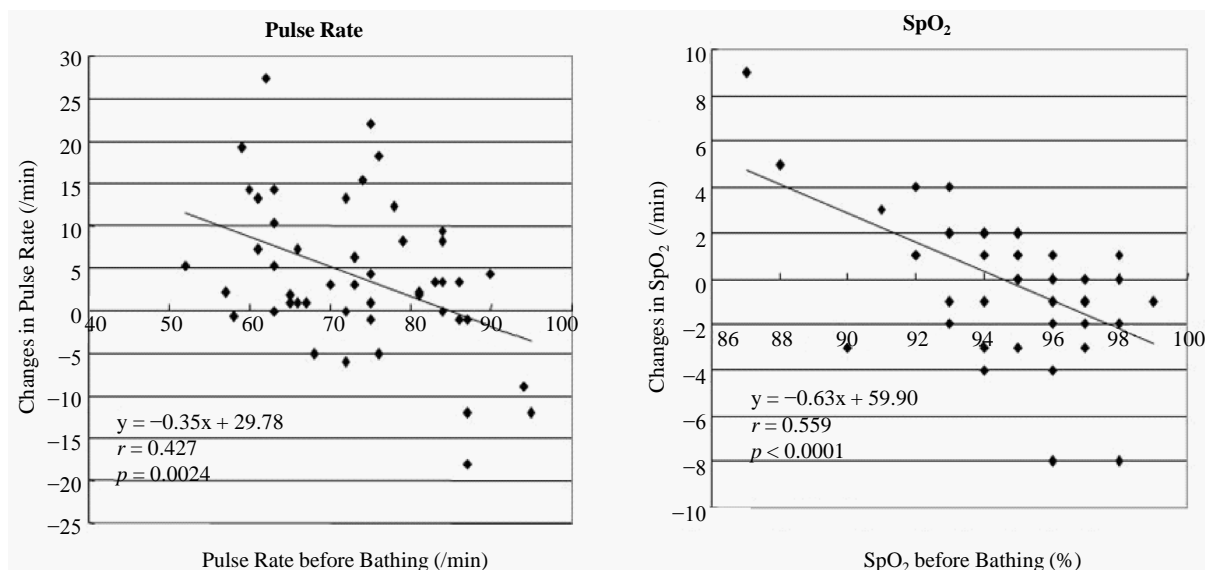
Values are expressed as mean ± SD. \**P* = 0.031 vs. before bathing.



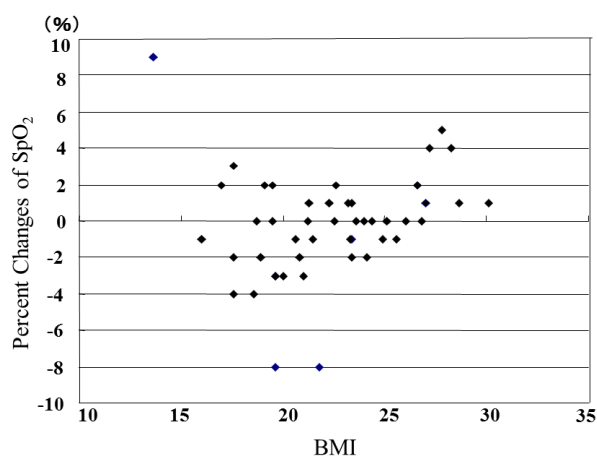
**Figure 1.** Relationship between blood pressure after and before bathing.



**Figure 2.** Relationship between changes in blood pressure after bathing and baseline systolic blood pressure before bathing.



**Figure 3.** Relationship between changes in pulse rate (left panel) and SpO<sub>2</sub> (right panel) during bathing and baseline value before bathing.



**Figure 4.** Relationship between BMI and percent changes of SpO<sub>2</sub> after bathing.

whereas in the elderly, blood pressure had a maximal value just at the start of immersion. Although heart rate increased in the young, it increased abruptly in the elderly. These results indicate that the nature of changes in blood pressure and heart rate during bathing remains unclear in the elderly. Most previous studies in this area have included few disabled patients. Thus, we hypothesized that discrepancies between such studies and the present study may have been caused by differences in basal physical conditions. In this study, the mean values of systolic and diastolic blood pressure before and after bathing showed no difference in the elderly participants in the nursing home. However, the changes in systolic blood pressure after bathing correlated negatively with the pressures before bathing. Blood pressure was reduced after bathing in participants with normal and high blood pressure and elevated in those with a blood pressure of <125 mmHg. Participants with pulse rates over 85/min experienced a decrease in pulse rate. Although our data do not provide information about the mechanism, we suggest that blood pressure was elevated because the venous return was increased by static hydro-pressure in the elderly who are more often dehydrated than younger individuals. As the elderly with systolic blood pressure of <125 mmHg showed marked elevation of blood pressure and pulse rate, they might be at higher risk of elevated blood pressure during bathing. The effect of bathing was less in individuals with high blood pressure. Concerning pulse rate, participants with tachycardia might be at higher risk of greater elevation in pulse rate

during bathing.

We measured SpO<sub>2</sub> as a reflection of the peripheral and central hemodynamics in the participants. As shown in **Figure 3**, SpO<sub>2</sub> ranged from 87% to 99%. Most of these elderly participants showed reduced peripheral circulation or respiratory function. Reduced SpO<sub>2</sub> was often experienced after exercise by patients with reduced respiratory function. In the present study, some lean participants whose SpO<sub>2</sub> levels were elevated might have had improved peripheral and central circulation after bathing. The reasons for the reduction in SpO<sub>2</sub> as seen in some participants are unclear; but possible mechanisms might involve reduced blood pressure, reduced lung volume in the water, or increased O<sub>2</sub> consumption. Shigeomi *et al.* [3] suggested that blood pressure changes during bathing should be controlled to prevent cardiac events. The present data suggest that the blood pressure of the elderly with standard physiques and in normal to slightly hypertensive persons showed similar trends to that in young individuals, while the elderly with lower blood pressure showed different trends in blood pressure during bathing. One limitation of this study is that observations were performed in a nursing care home in which bath temperatures were lower and bathing times were shorter than those in the typical family home.

## 5. Conclusion

Changes in blood pressure, heart rate, and SpO<sub>2</sub> after bathing showed an inverse correlation with those before bathing in the elderly in a nursing home. Elderly individuals with blood pressures of <125 mmHg may be at higher risk of increased blood pressure during bathing.

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