Hot spring bathing is associated with a lower prevalence of hypertension among Japanese older adults: A cross-sectional study in Beppu

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Research Article

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Abstract

Background: Hot spring bathing is practiced to manage various diseases, including hypertension. We investigated the preventive effects on hypertension of hot spring bathing for older adults in a data analysis using responses to a previous questionnaire with the aim to identify a novel approach in the prevention and management of hypertension.

Methods: Among 10428 adults aged ≥ 65 years, we assessed the hot spring bathing habits in the 4001 subjects with a history of hypertension. Odds ratios (OR) with 95% confidence intervals (CIs) were calculated using a multivariable logistic regression model for the history of hypertension.

Results: In a multivariable logistic regression model, age (≥ 85 years; OR, 1.410; 95% CI, 1.180–1.690), history of arrhythmia (OR, 1.580; 95% CI, 1.380–1.820), stroke (OR, 1.590; 95% CI, 1.280–1.980), gout (OR, 1.900; 95% CI, 1.540–2.330), diabetes mellitus (OR, 1.470; 95% CI, 1.310–1.650), hyperlipidemia (OR, 1.680; 95% CI, 1.490–1.910), renal disease (OR, 1.500; 95% CI, 1.220–1.860) chronic hepatitis (OR, 0.648; 95% CI, 0.494–0.849), and hot spring bathing for 20–29 min (OR, 0.817; 95% CI, 0.715–0.934) and at 19:00 or later (OR, 0.884; 95% CI, 0.715–0.934) were independently and significantly associated with hypertension during the lifetime.

Conclusions: These results support our hypothesis that habitual nighttime hot spring bathing is associated with improved hypertension control. The findings suggest that nighttime hot spring bathing might help in preventing hypertension owing to chronic stress-induced sleep disturbance in adults aged ≥ 65 years.

Background

Hypertension is the leading reason for visiting a hospital and for the long-term use of prescription medications [1, 2, 3]. In Japan, $\geq 60\%$ of men aged ≥ 50 years and of women aged ≥ 60 years had hypertension in 2016 [4]. In the United States, although the proportion of adults with blood pressure above the target increased from 39–53%, the proportion of adults with a recommendation for antihypertensive medication increased from 34–36%, according to pooled data from 2011 to 2014. Most patients classified as above goal require nonpharmacologic intervention as initial therapy [2]. Additionally, owing to multiple stressors encountered within their occupation, groups including military personnel, firefighters, and police officers have an elevated risk for the development of cardiometabolic diseases such as atherosclerosis [5], heart disease [6] and sudden cardiac death [7], which are related to hypertension [8].

Hot spring bathing has expanded globally from Japan and Asia. Maeda et al. reported preventive effects on the occurrence of hypertension in older women [9]. However, details regarding the relationship between hot spring bathing and hypertension remain unknown.

The aim of this retrospective study was to investigate the preventive effects on hypertension of hot spring bathing for older adults in a data analysis using responses to a previous questionnaire with the aim to identify a novel approach in the prevention and management of hypertension.

Methods

Participant selection

We retrospectively reviewed data from a questionnaire survey conducted in 2011 with 11,146 responses from individuals aged ≥ 65 years who were living in Beppu city [9]. In that year, there were 34,465 residents of Beppu city in the age group ≥ 65 years. Questionnaires regarding hot spring bathing habits and disease history were randomly sent to 20,000 of these residents. We analyzed responses from a total of 10,429 survey participants regarding age, sex, disease history, and hot spring bathing habits (Table 1).

Table 1
Characteristics of survey respondents

		Total	Hypertension	
Characteristic		n = 10428	n = 4001	P
Age, n (%)				
65–69 years old		3121 (29.9)	1072 (26.7)	< 0.001
70–74 years old		2898 (27.7)	1064 (26.6)	
75–79 years old		2514 (24.1)	1019 (25.5)	
80–84 years old		1265 (12.1)	573 (14.3)	
≥ 85 years old		630 (6.0)	263 (6.8)	
Sex, n (%)	Male	4471 (42.8)	1764 (44.1)	0.048
	Female	5957 (57.1)	2237 (55.9)	
Disease history, n (%)				
Cancer		1163 (11.1)	431 (10.8)	0.346
Depression		219 (2.1)	88 (2.2)	0.625
Ischemic heart disease		724 (6.9)	327 (8.2)	< 0.001
Arrhythmia		938 (8.9)	471 (11.8)	< 0.001
Stroke		354 (3.3)	180 (4.5)	< 0.001
Gout		416 (3.9)	230 (5.7)	< 0.001
Asthma		395 (3.7)	166 (4.1)	0.141
Diabetes mellitus		1427 (13.6)	667 (16.7)	< 0.001
Hyperlipidemia		1154 (11.0)	578 (14.4)	< 0.001
Renal disease		373 (3.5)	191 (4.8)	< 0.001
Chronic hepatitis		267 (2.5)	78 (1.9)	0.002
Collagen disease		216 (2.0)	86 (2.1)	0.710
Allergy		572 (5.4)	217 (5.4)	0.835
Hot spring-bathing, n (%)				
Frequency				

The p -values were obtained using the chi-square test.

	Total	Hypertension	
<1/month	2924 (28.0)	1181 (29.5)	0.0013
1/month-1/week	356 (3.4)	136 (3.4)	
2–3/week	871 (8.3)	361 (9.0)	
4–5/week	1394 (13.3)	514 (12.8)	
Daily	4884 (46.8)	1809 (45.2)	
Duration of immersion			
<10 min	2645 (25.3)	1108 (27.7)	< 0.001
10–19 min	4304 (41.2)	1613 (40.3)	
20–29 min	2616 (25.0)	973 (24.3)	
≥30 min	864 (8.2)	307 (7.7)	
Years of habit			
<10 years	3021 (28.9)	1225 (30.6)	0.011
10–19 years	1324 (12.6)	486 (12.1)	
20–29 years	1034 (9.9)	380 (9.5)	
30–39 years	1113 (10.6)	406 (10.1)	
≥40 years	3076 (29.4)	1197 (29.9)	
Time			
Before 9:00	1272 (12.1)	508 (12.7)	< 0.001
9:00 to 13:00	1145 (10.9)	433 (10.8)	
13:00 to 19:00	4087 (39.1)	1653 (41.3)	
19:00 or after	3925 (37.6)	1407 (52.1)	
Hot spring type			
Simple	2193 (21.0)	852 (21.3)	0.864
Chloride	1116 (10.7)	430 (10.7)	0.846
Bicarbonate	329 (3.1)	113 (2.8)	0.077
Sulfur	87 (0.8)	37 (0.9)	0.509
Iron	23 (0.2)	12 (0.3)	0.294
The p -values were obtained using the chi-square test.			

	Total	Hypertension	
Sulfate	16 (0.1)	8 (0.2)	0.441
Carbon dioxide	14 (0.1)	2	0.095
Acid	1	1	0.384
Aluminum	1	1	0.384
The p -values were obtained using the chi-square test.			

The examined variables were as follows: age; sex; disease history during the lifetime including depression, ischemic heart disease, arrhythmia, hypertension, stroke, gout, asthma, diabetes mellitus, hyperlipidemia, renal disease, chronic hepatitis, collagen disease, and allergy; and hot spring bathing habits including frequency, duration of immersion, years of habitual bathing, typical time of bathing, and type of hot spring. Informed consent to participate in the study was obtained by providing participants with information on our hospital website. The study was performed in accordance with the institutional guidelines and the principles of the Declaration of Helsinki. The protocol was approved by the institutional review board.

Statistical methods

We analyzed the frequencies and descriptive statistics of participant variables. Intergroup differences in categorical variables were expressed as number and percentage. The chi-square statistical method was used for testing the relationships between categorical variables. Univariable and multivariable logistic regression models were used to determine associations between variables and the prevalence of hypertension. Covariates that were significant at $p < 0.05$ in univariate analysis were included in the multivariate analysis. All tests were two-sided. We calculated 95% confidence intervals, and $p < 0.05$ was considered statistically significant. Analyses were conducted using EZR (Saitama Medical Center, Saitama, Japan; <http://www.jichi.ac.jp/saitama-sct/SaitamaHP.files/statmedEN.html>) [10], which is a graphical user interface for R version 2.13.0 (www.r-project.org), and a modified version of R Commander version 1.6-3 designed to add statistical functions.

Results

Overall, 4001 of 10,428 participants (38.3%) had the prevalence of hypertension. The baseline characteristics of participants with hypertension during the lifetime are presented in Table 1. In a univariable logistic regression model, age ≥ 85 years, female sex, arrhythmia, stroke, gout, diabetes mellitus, hyperlipidemia, renal disease, chronic hepatitis, and hot spring bathing frequency (2–3 times/week and daily), duration of immersion (10–19 min and 20–29 min), bathing time (13:00 to 19:00 and 19:00 or later), and years of habitual hot spring bathing (10–19 years) were significantly associated with influencing hypertension during the lifetime (Table 2). In a multivariable logistic regression model, age ≥ 85 years, arrhythmia, stroke, gout, diabetes mellitus, hyperlipidemia, renal disease, chronic

hepatitis, and hot spring duration of immersion (20–29 min) and bathing time (19:00 or later) were significantly associated with the prevalence of hypertension during the lifetime (Table 2). These findings support the hypothesis that hypertension can be predicted with habitual nighttime hot spring bathing.

Table 2
Univariable and multivariable analysis of variables influencing history of hypertension

Variable	Univariable			Multivariable		
	OR	95% CI	p	OR	95% CI	p
Age 65–69 years old	1.000	reference				
70–74 years old	1.110	0.998–1.230	0.055			
75–79 years old	0.891	0.747–1.060	0.202			
80–84 years old	1.080	0.893–1.310	0.418			
≥ 85 years old	1.460	1.230–1.740	< 0.001	1.410	1.180–1.690	< 0.001
Sex Male	1.000	reference				
Female	0.923	0.852–0.999	0.048	1.030	0.948–1.120	0.474
Disease history						
Cancer	1.000	reference				
Depression	0.970	0.733–1.280	0.830			
Ischemic heart disease	1.150	0.985–1.350	0.076			
Arrhythmia	1.610	1.400–1.850	< 0.001	1.580	1.380–1.820	< 0.001
Stroke	1.620	1.310–2.010	< 0.001	1.590	1.280–1.980	< 0.001
Gout	1.860	1.520–2.280	< 0.001	1.900	1.540–2.330	< 0.001
Asthma	1.130	0.914–1.390	0.265			
Diabetes mellitus	1.460	1.300–1.630	< 0.001	1.470	1.310–1.650	< 0.001
Hyperlipidemia	1.650	1.460–1.870	< 0.001	1.680	1.490–1.910	< 0.001
Renal disease	1.520	1.230–1.880	< 0.001	1.500	1.220–1.860	< 0.001
Chronic hepatitis	0.656	0.500–0.859	0.002	0.648	0.494–0.849	0.0016
Collagen disease	1.030	0.774–1.360	0.861			
Allergy	0.942	0.789–1.130	0.509			
Hot spring-bathing frequency						

OR, odds ratio; CI, confidence interval.

[†]Univariable or multivariable competing event statistics analyzed using a logistic regression model were applied to a positive history of hypertension. Covariates significant at $p < 0.05$ in univariate analysis were included in the multivariate analysis.

	Univariable			Multivariable		
< 1/month	1.000	reference				
1/month-1/week	0.912	0.728–1.140	0.427			
2–3/week	1.200	1.040–1.390	0.013			
4–5/week	0.994	0.879–1.120	0.924			
Daily	0.868	0.790–0.954	0.003	0.932	0.821–1.060	0.281
Duration of immersion						
<10 min	1.000	reference				
10–19 min	0.832	0.753–0.918	< 0.001			
20–29 min	0.765	0.652–0.897	< 0.001	0.817	0.715–0.934	0.0030
≥ 30 min	0.931	0.793–1.090	0.380			
Time						
Before 9:00	1.000	reference				
9:00 to 13:00	0.915	0.776–1.080	0.286			
13:00 to 19:00	1.220	1.110–1.330	< 0.001			
19:00 or after	0.840	0.738–0.957	0.008	0.884	0.715–0.934	0.0030
Years of habit						
< 10 years	1.000	reference				
10–19 years	0.851	0.745–0.973	0.017	0.884	0.754–1.040	0.129
20–29 years	1.050	0.869–1.270	0.622			
30–39 years	1.040	0.861–1.250	0.706			
≥ 40 years	1.150	0.982–1.350	0.082			
Hot spring type						
Simple	0.982	0.889–1.080	0.714			
Chloride	0.977	0.858–1.110	0.722			

OR, odds ratio; CI, confidence interval.

[†]Univariable or multivariable competing event statistics analyzed using a logistic regression model were applied to a positive history of hypertension. Covariates significant at $p < 0.05$ in univariate analysis were included in the multivariate analysis.

	Univariable		Multivariable
Bicarbonate	0.805	0.638–1.010	0.065
Sulfur	1.150	0.752–1.760	0.515
Iron	1.590	0.712–3.540	0.258
Sulfate	1.590	0.595–4.240	0.356
Carbon dioxide	0.265	0.059–1.180	0.081
OR, odds ratio; CI, confidence interval.			
†Univariable or multivariable competing event statistics analyzed using a logistic regression model were applied to a positive history of hypertension. Covariates significant at $p < 0.05$ in univariate analysis were included in the multivariate analysis.			

Discussion

Traditional thermal therapy and hot spring bathing have proven useful for various diseases, including hypertension [11]. We investigated the preventive effects of long-term hot spring bathing in adults aged ≥ 65 years. We found that age ≥ 85 years; history of arrhythmia, stroke, gout, diabetes mellitus, hyperlipidemia, and renal disease were independently and significantly associated with a higher risk of developing hypertension during the lifetime. We found that history of chronic hepatitis; and hot spring bathing duration and time were independently and significantly protective against hypertension development during the lifetime. These results support our hypothesis that habitual nighttime hot spring bathing is protective against hypertension development.

The implications of our data can be extrapolated in comparisons regarding the prevalence of hypertension according to questionnaire survey responses in adults aged ≥ 65 years. We found that nighttime hot spring bathing, which can improve sleep disorders, might be associated with the prevention of hypertension in adults aged ≥ 65 years. In a large-scale study among an older population, Tai et al. reported that nighttime hot spring bathing is significantly associated with shorter sleep onset latency and higher distal–proximal skin temperature gradient [12]. Sawatari et al. suggested that leg thermal therapy could improve subjective and objective sleep quality in patients with chronic heart failure [13]. The COVID-19 pandemic has placed all people at risk for developing psychiatric and mental health disorders, including sleep disturbances [14]. It is therefore possible that nighttime hot spring bathing may improve sleep, with may result in improving hypertension control [15].

According to our data, age ≥ 85 years was significantly associated with the prevalence of hypertension. Many risk factors are associated with hypertension development, such as age, obesity, family history, high-sodium diet, and physical inactivity [16, 17]. Regarding disease history, stroke [18] and renal disease [19, 20] are associated with hypertension. Given that health care spending on hypertension exceeded USD 70 billion in the United States between 1996 and 2016 [21], clinicians and researchers have great interest

in proactive and preventive interventions versus reactive approaches for hypertension. In this study, we demonstrated that an alternative option for potentially improving hypertension control in adults aged ≥ 65 years is habitual nighttime hot spring bathing.

Stress has two components: an acute phase and a chronic phase [22]. Rozanski et al. verified a direct association between cardiovascular disease and chronic stress, which is known to modulate vascular endothelial cell function and platelet aggregation [23]. Dual stressors include psychological and physiological stressors and are known to elicit activation of the hypothalamic and sympathoadrenal axes and a subsequent greater release of stress markers such as cortisol, epinephrine, and norepinephrine, in comparison with a single stressor [24, 25]. Increased levels of cortisol and oxidative stress in the body can upregulate several proinflammatory pathways, which can result in the development of several cardiovascular diseases including hypertension [26]. Endocrine responses to sauna bathing show that some markers of stress, such as cortisol, β -endorphins, and adrenocorticotrophic hormone, respond to acute heat exposure in a highly variable manner [27]. Different results regarding the hormone response are likely owing to differences in study methods and consideration of factors such as therapy duration, time, and frequency, which were considered in our study. Therefore, revealing the cardiovascular responses will provide a more comprehensive picture of the physiological responses to hot spring bathing. Sauna baths have decreased blood pressure compared with pre-sauna measures [28]. Although brief exposures to sauna baths resulted in benefits for < 1 hour, including reduction of blood pressure and improvement of arterial stiffness, ≥ 3 weeks and repeated exposures upregulated enzymes and pathways, which resulted in inducing stress tolerance, stronger cellular environment, and elevated health [29]. Due to a lack of adherence to physical activity and nutrition interventions and the time pressures among individuals aged ≥ 65 years, practical interventions that can prevent or improve hypertension, such as habitual hot spring bathing, warrant additional attention.

Our study has some limitations that should be acknowledged. First, some selection bias is expected with use of questionnaire surveys; however, bias is present owing to differences in data selection. Second, important data regarding the prevalence of hypertension was likely missing because this information was collected using self-report questionnaires. To minimize bias, we limited the inclusion criteria to age, sex, disease history, and hot spring bathing habits. Third, we have no data about the treatment and outcomes of hypertension; further studies are needed to assess the details of treatment and outcomes in patients with hypertension. Finally, the purpose of this study was to help clarify the relationship between prevention of hypertension and habitual hot spring bathing. However, it was difficult to interpret the obtained evidence, such as the interactions among duration of immersion, frequency, time, and years of habitual hot spring bathing because we did not evaluate the quality of the questionnaire data.

Conclusions

In conclusion, we found that habitual nighttime hot spring bathing was significantly associated with a lower prevalence of hypertension in older adults. It is important to prioritize clinical trials regarding the prevalence of hypertension, including identifying effective approaches to the monitoring and

management of arrhythmia, stroke, gout, diabetes mellitus, hyperlipidemia, renal disease, and chronic hepatitis. Our findings suggest that nighttime hot spring bathing can help to reduce stress, improve sleep disorders, and reduce the incidence of hypertension.

Declarations

Ethics approval and Consent to Participate

This was a retrospective study with no experimental interventions. The study was approved by the Institutional Review Board of Kyushu University Hospital in Japan. The study was performed in accordance with the institutional guidelines and the principles of the Declaration of Helsinki. Informed consent was obtained from all individual participants included in the study.

Consent for publication

Not applicable.

Availability of data and material

We used data obtained from a questionnaire performed in 2011 in Beppu, Japan. The datasets generated and analyzed during the current study are not publicly available due to privacy and confidentiality restrictions pertaining to person-level health information. However, the dataset creation plan is available from the corresponding author on reasonable request.

Competing interest

All authors declare that they have no competing interest.

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Authors' Contributions

S. Y. designed the study, analyzed the data, and prepared the manuscript. S. Y., T. T., T. M., and T. H. prepared and reviewed the manuscript.

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