RESEARCH ARTICLE

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The Association between Habitual Tub Bathing and Risk of Breast Cancer: The Japan Public Health Center-Based Prospective Study

Naoya Teraoka[1], Isao Muraki[1], Hiroyasu Iso[2]*, Ryo Kawasaki[1], Manami Inoue[3], Shoichiro Tsugane[3,4], Norie Sawada[3], for the Japan Public Health Center-based Prospective (JPHC) Study Group[a]

Abstract

Background: Several studies reported that hot tub bathing, a unique Japanese culture, may benefit breast cancer risk factors. It is, however, uncertain whether moderate heat exposure through hot tub bathing could potentially reduce the risk of breast cancer. In this study, we aimed to investigate this association through a long-term prospective cohort study conducted in Japan. **Methods:** A total of 15,927 Japanese women aged 40–59 years with no history of breast cancer were followed up from 1990 to 2015. The frequency of tub bathing was categorized as 0–2 days/week, 3–4 days/week, and almost every day. The hazard ratios (HRs) and 95% confidence intervals (CIs) for the incident breast cancer were estimated using Cox proportional hazards models after adjusting for potential risk factors for breast cancer, including overweight. **Results:** During 367,950 person-years of the follow-up period, 370 breast cancer cases were identified. After adjusting for known confounders for breast cancer risk, the multivariable HR (95% CI) of incident breast cancer was 1.23 (0.93–1.62) for 3-4 days/week and 0.72 (0.40-1.31) for ≤2 days/week (trend p=0.90), compared to almost every day of tub bathing (p for trend = 0.90). No association was also seen for pre-menopausal or post-menopausal women and subjective lukewarm, warm, or hot bath temperatures. **Conclusion:** We found no reduced risk of breast cancer for women associated with frequent tub bathing. Further research is needed to obtain objective information on the frequency, duration, and water temperature of tub bathing.

Keywords: Tub bathing- risk factor- breast cancer- prospective cohort study

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Introduction

Breast cancer has the highest incidence rate of site-specific cancers among Japanese women. It is the fourth leading cause of cancer-related death, with an increasing trend for its incidence and mortality [1]. On the other hand, the cumulative incidence of breast cancer among East Asian countries, including Japan, is lower than in North America and European regions [2, 3]. The lower incidence of breast cancer in Japanese women can be due to lower levels of lifestyle-related risk factors [4-7], such as lower body mass index, low prevalence of smoking, lower alcohol consumption, and a high intake of soy products [8, 9].

A unique habit of bathing in Japan is soaking in hot water up to the shoulders in a deep tub, usually in the evening, to warm the body, recover from fatigue, relax, refresh, and improve sleep [10]. In contrast, Western-style bathing is soaking in lukewarm or warm water up to the chest in a shallow tub [11].

Hot tub bathing was reported to benefit breast cancer risk factors such as weight loss in Japanese [12]. On the other hand, short sleep time is a possible risk factor for breast cancer in the Japanese population [13]. Furthermore, local or regional hyperthermia therapy combined with radiotherapy has been conducted in combination with standard treatment of breast cancer [14]. A meta-analysis of five randomized clinical trials [15] and two separate trials [16, 17] of hyperthermia therapy have demonstrated the effectiveness of tumor control. Therefore, hot tub

*[1]Public Health, Department of Social Medicine, Osaka University Graduate School of Medicine, 2-2 Yamadaoka, Suita, Osaka 565-0871, Japan. [2]The Institute for Global Health Policy Research, National Center for Global Health and Medicine, 1-21-1 Toyama Shinjuku-ku, Tokyo 162-8655, Japan. [3]Division of Cohort Research, National Cancer Center Institute for Cancer Control, 5-1-1 Tsukiji, Chuo-ku, Tokyo 104-0045, Japan. [4]International University of Health and Welfare Graduate School of Public Health, 4-1-26 Akasaka, Minato-ku, Tokyo 107-8402, Japan. [a]JPHC members are listed at the following site (as of April 2018); https://epi.ncc.go.jp/en/jphc/781/8233.html. *For Correspondence: hiso@it.ncgm.go.jp*

bathing could lower the risk of breast cancer by improving risk factors of breast cancer and a potential hyperthermic treatment effect on preclinical breast cancer because the breast is a superficial organ that can be efficiently heated while soaking in hot water.

No prospective cohort study has explored the association between traditional Japanese hot tub bathing and the risk of breast cancer, while potential health benefits were reported, including lower risks of coronary heart disease and stroke [18] in middle-aged adults, reduced functional disability [19], and dementia [20] in the elderly.

The present study aimed to investigate whether tub bathing is associated with the risk of breast cancer among Japanese women in a long-term, large-scale prospective study, the Japan Public Health Center-based (JPHC) Study.

Materials and Methods

Study population

The JPHC Study, a population-based prospective study, included two cohorts: Cohort I, established in 1990, and Cohort II, established in 1993. In this study, we limited women to Cohort I, where habitual tub bathing was asked. The JPHC Study Cohort I was established in 1990 by enrolling 31,615 women aged 40–59 from five public health center areas (i.e., Akita, Iwate, Tokyo, Nagano, and Okinawa). The study design was detailed in a previous article [21].

To investigate the association between tub bathing and risk of incident breast cancer, we included 31,615 women from that cohort. Of 31,615 women, we excluded 4,178 participants from Tokyo because of the incomplete data on the cancer incidence in the Tokyo area, and 6,897 participants from Okinawa, where bathing habits differ considerably from in other parts of mainland Japan; only 10.8% of participants in Okinawa took tub baths almost every day while 71.9% of those in Akita, Iwate, and Nagano did. Among 20,540 women, we excluded 50 participants who were disqualified (non-Japanese nationality, incorrect late report of migration occurring before the starting point, or incorrect birth data), had died, moved out of a study area, or were lost to follow-up before the starting point and 3,393 participants without the response to questionnaires. Among 17,097 responders (response rate: 83.4%), we also excluded 502 participants with a history of any cancer and 668 participants without valid data on tub bathing. Finally, 15,927 participants were included in the present analysis (Figure 1).

The Institutional Human Ethics Review Boards of the National Cancer Center (approval number: 2001-021, 2015-085) and Osaka University Hospital (approval number: 14285) approved the study. All research participants were informed of the study objectives at their enrollment. Written informed consent was not obtained, but we considered that participants understood the study's aim and expressed their intention to participate when they completed the baseline questionnaire.

Measurements of tub bathing frequency and covariates

Participants were asked their frequency of tub bathing with the following question, "How often do you bathe in a tub in one week?" and responded by choosing one from four possible responses: "Less than once a week on average", "1–2 days/week", "3–4 days/week", and "almost daily or every day". As only 108 (0.68%) participants did tub bathing less than once a week, we combined the two lowest frequencies as ≤2 days/week. Subjective bath water temperature was asked to be lukewarm, warm, or hot.

From the baseline questionnaires, we also obtained information on height, weight, smoking status, alcohol consumption, regular physical exercise, history of hypertension and diabetes, and family history of breast cancer. As reproductive factors, we asked about age at menarche, age at first delivery, number of deliveries, menopausal status and age at menopause, exogenous hormone use, and history of breastfeeding. Body mass index (BMI) was calculated as the reported weight (kg) divided by height squared (m^2).

Follow-up and confirmation of breast cancer

Our study's accuracy and validity were ensured through a meticulous follow-up and confirmation process of breast cancer cases. Participants were tracked from when they responded to the baseline survey until December 31, 2015. During the follow-up, 3,205 (20.1%) participants were censored due to move-out from the community (n = 1,216) and death (n = 1,989). Newly diagnosed breast cancer cases were confirmed using population-based cancer registries and hospital records in the study areas. These cases were coded using the ICD-O-3; breast cancer was coded as C500-509. The death certificate only (DCO) was 0.81%. The percentage of histologically confirmed cases was an impressive 96.5%.

The residential registry in the study area tracked any annual change in residence or survival status. Participants moving out from their original living area were censored on the last date that confirmed their presence. Information on the cause of death was confirmed by examining death certificates provided by the Ministry of Health, Labour, and Welfare with permission from the Ministry of Internal Affairs and Communications.

Statistical Analysis

For each participant, we calculated the person-years of follow-up as the duration from the date of response to the date of the following events whichever came first: the first incidence of breast cancer, death, emigration, or the end of the follow-up. The mean value and proportion of potential confounding factors were calculated according to tub bathing frequency. The trend test across the tub bathing frequency was performed using linear regression for continuous variables and logistic regression for categorical variables.

The hazard ratio (HR) and its 95% confidence interval (CI) of incident breast cancer were calculated using the Cox proportional hazard models according to the frequency of tub bathing, subjective tub temperature, and their combination. The proportional hazard assumptions were examined with Schoenfeld residuals, and no violation was found. We adjusted for the following potential confounding factors: age (continuous), public health center area (five areas), smoking status (never, former,

current smokers, and missing), alcohol consumption (<23, ≥23 g ethanol/occasion, and missing), regular physical exercise (<1, ≥1 times/week, and missing), family history of breast cancer (no, yes, and missing), menopause status and age at menopause (pre-menopause, <49, ≥49 years, and missing), ages at menarche (≤13, 14, 15, ≥16 years, and missing), and first delivery (<26, ≥26 years, or missing), number of deliveries (0, 1-2, 3, ≥4 deliveries, and missing), exogenous hormone use (no, yes, and missing), and history of breastfeeding (no, yes, and missing). We further adjusted BMI (<18.5, 18.5-21.9, 22.0-24.9, 25.0-29.9, ≥30.0 kg/m^2, and missing), a risk factor for breast cancer among Japanese women [6]. We used SAS version 9.4 (SAS Institute Inc, Cary, NC) for the statistical analyses. All statistical tests were two-tailed, and p-values <0.05 were considered statistically significant.

Results

Table 1 shows the baseline characteristics according to the frequency of tub bathing. Participants who soaked in a tub almost daily accounted for the largest proportion of participants at 73.8%. Those who soaked in a tub almost daily were less likely to be overweight, have histories of diabetes and hypertension, and were more likely to have a family history of breast cancer, current drinking behavior, and leisure-time sports engagements. There was an inverse trend for age, BMI, leisure-time sports engagement, and a history of hypertension according to subjective tub bathing temperature.

During 367,950 person-years of follow-up, we documented 370 incident cases of breast cancer (Table 2). There was no association between the frequency of tub

Table 1. Baseline Characteristics of Female Participants According to the Frequency of Tub Bathing

	Frequency of tub bathing			P for	Bath water temperature			P for
	Almost daily	3-4 days/week	≤2 days/week	trend	Lukewarm	Warm	Hot	trend
N	11,741	3,344	842		1,418	11,120	3,389	
Age, years*	49.7 ± 5.9	49.7 ± 5.8	50.4 ± 5.9	0.007	50.8 ± 5.9	49.8 ± 5.8	49.1 ± 5.9	<0.001
Body mass index, kg/m2*	23.3 ± 3.0	23.5 ± 3.2	23.4 ± 3.3	0.070	23.5 ± 3.2	23.4 ±3.0	23.3 ± 3.1	0.03
Overweight ≥25.0 of BMI, n (%)	3,047 (26.1)	934 (28.2)	244 (29.8)	0.002	394 (28.1)	2,944 (26.6)	887 (26.3)	0.28
History of diabetes, n (%)	267 (2.3)	91 (2.7)	29 (3.5)	0.020	41 (2.9)	272 (2.5)	74 (2.2)	0.15
History of hypertension, n (%)	1,612 (13.8)	527 (15.9)	136 (16.3)	0.001	297 (21.2)	1,612 (14.6)	366 (10.9)	<0.001
Family history of breast cancer, n (%)	148 (1.3)	37 (1.1)	5 (0.6)	0.100	21 (1.5)	129 (1.2)	40 (1.2)	0.54
Current drinker, n (%)	1,479 (12.7)	367 (11.1)	68 (8.1)	<0.001	184 (13.0)	1,290 (11.7)	440 (13.0)	0.39
Current smoker, n (%)	587 (5.0)	190 (5.7)	39 (4.7)	0.160	99 (7.0)	525 (4.7)	192 (5.7)	0.55
Leisure-time sports ≥1 time/week, n (%)	1,686 (14.6)	409 (12.4)	77 (9.4)	<0.001	214 (15.4)	1,518 (13.9)	440 (13.1)	0.05
Age at menarche, n (%)				<0.001				0.67
13 years	3,179 (27.1)	957 (28.6)	220 (26.1)		391 (27.6)	3,031 (27.3)	934 (27.6)	
14 years	2,829 (24.1)	825 (24.7)	163 (19.4)		314 (22.1)	2668 (24.0)	835 (24.6)	
15 years	2,666 (22.7)	672 (20.1)	195 (23.2)		313 (22.1)	2476 (22.3)	744 (22.0)	
≥16 years	2,678 (22.8)	739 (22.1)	216 (25.7)		342 (24.1)	2529 (22.7)	762 (22.5)	
Missing	389 (3.3)	151 (4.5)	48 (5.7)		58 (4.1)	416 (3.7)	114 (3.4)	
Age at menopause, n (%)				<0.001				<0.001
Pre-menopause	5,267 (45.2)	1,458 (44.3)	324 (39.9)		514 (36.8)	4,888 (44.4)	1,647 (49.2)	
<49 years	2,844 (24.4)	782 (23.8)	203 (25.0)		391 (28.0)	2,653 (24.1)	785 (23.4)	
≥49 years	3,391 (29.1)	978 (29.7)	256 (31.5)		473 (33.9)	3,291 (29.9)	861 (25.7)	
Missing	147 (1.3)	73 (2.2)	30 (3.7)		17 (1.2)	177 (1.6)	56 (1.7)	
Post-menopausal hormone use, n (%)				0.080				0.45
Yes	2,281 (19.4)	687 (20.5)	186 (22.1)		306 (21.6)	2,175 (19.6)	673 (19.9)	
No	8,796 (74.9)	2,476 (74.0)	598 (71.0)		1,036 (73.1)	8,304 (74.7)	2,530 (74.7)	
Missing	664 (5.7)	181 (5.4)	58 (6.9)		76 (5.4)	641 (5.8)	186 (5.5)	
No. of delivery, n (%)				<0.001				0.44
None	492 (4.2)	187 (5.6)	72 (8.6)		79 (5.6)	508 (4.6)	164 (4.8)	
1-2 times	5,752 (49.0)	1,320 (39.5)	310 (36.8)		660 (46.5)	5,138 (46.2)	1,584 (46.7)	
3 times	3,592 (30.6)	1,114 (33.3)	218 (25.9)		409 (28.8)	3,467 (31.2)	1,048 (30.9)	
≥4 times	1,239 (10.6)	554 (16.6)	186 (22.1)		180 (12.7)	1,381 (12.4)	418 (12.3)	
Missing	666 (5.7)	169 (5.1)	56 (6.7)		90 (6.3)	626 (5.6)	175 (5.2)	
Breastfeed, n (%)				0.007				0.002
Yes	9,142 (77.9)	2,620 (78.3)	619 (73.5)		1,101 (77.6)	8,699 (78.2)	2,581 (76.2)	
No	1,596 (13.6)	379 (11.3)	112 (13.3)		161 (11.4)	1,425 (12.8)	501 (14.8)	
Missing	1,003 (8.5)	345 (10.3)	111 (13.2)		156 (11.0)	996 (9.0)	307 (9.1)	

*, Mean (Standard deviation)

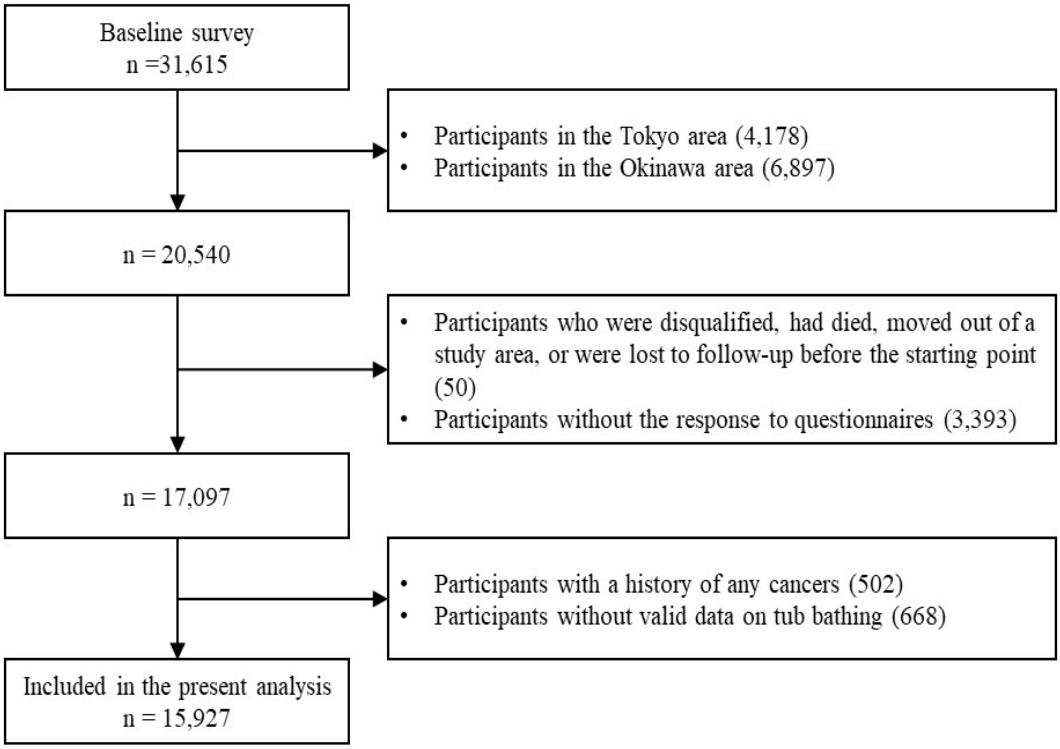

Figure 1. Flowchart for the Study Selection Process

bathing and the risk of incident breast cancer among total participants. Compared to almost daily tub bathing, the multivariable HR (95% CI) of incident breast cancer was 1.23 (0.93–1.62) for 3-4 days/week and 0.72 (0.40-1.31) for ≤2 days/week (p for trend=0.90). Further adjustment for BMI did not substantially change these associations. When stratifying by menopausal status, significant associations between tub bathing frequency and incident breast cancer were not observed.

The association between subjective tub bathing

Table 2. The Association between the Frequency of Tub Bathing and Risk of Breast Cancer

	Frequency of tub bathing			
	Almost daily	3-4 days/week	≤2 days/week	p for trend
Total participants				
Person-years	272,245	76,399	19,306	
No. of case	276	82	12	
Age, area-adjusted HR	1	1.23 (0.93-1.61)	0.72 (0.40-1.30)	0.91
Multivariable HR*	1	1.23 (0.94-1.62)	0.72 (0.40-1.31)	0.90
Multivariable HR**	1	1.24 (0.94-1.63)	0.73 (0.40-1.32)	0.87
Pre-menopause				
Person-years	122,559	33,459	7,545	
No. of case	132	36	10	
Age, area-adjusted HR	1	1.14 (0.76-1.71)	1.42 (0.73-2.79)	0.28
Multivariable HR*	1	1.11 (0.74-1.67)	1.32 (0.67-2.61)	0.39
Multivariable HR**	1	1.11 (0.74-1.66)	1.32 (0.67-2.63)	0.39
Post-menopause				
Person-years	146,239	41,294	11,067	
No. of case	141	43	2	
Age, area-adjusted HR	1	1.29 (0.88-1.89)	0.22 (0.05-0.92)	0.45
Multivariable HR*	1	1.31 (0.89-1.93)	0.23 (0.06-0.95)	0.49
Multivariable HR**	1	1.34 (0.91-1.97)	0.24 (0.06-0.98)	0.57

HR, hazard ratio; 95% CI, 95% confidence interval; *Adjusted further for family history of breast cancer, alcohol intake, smoking status, age at menarche; age at first delivery, number of deliveries, menopausal status, age at menopause, use of post-menopausal; hormone, and leisure time physical activity; **, Adjusted further for body mass index.

Table 3. The Association between Bath Water Temperature and Risk of Breast Cancer

	Bath water temperature			
	Lukewarm	Warm	Hot	p for trend
Total participants				
Person-years	32,056	256,892	78,405	
No. of case	31	257	81	
Age, area-adjusted HR	0.97 (0.66-1.40)	1	1.03 (0.80-1.33)	0.74
Multivariable HR*	0.96 (0.66-1.40)	1	1.02 (0.79-1.31)	0.79
Multivariable HR**	0.96 (0.66-1.39)	1	1.02 (0.79-1.31)	0.78
Pre-menopause				
Person-years	11,529	113,586	38,294	
No. of case	12	120	46	
Age, area-adjusted HR	0.97 (0.53-1.75)	1	1.14 (0.81-1.60)	0.46
Multivariable HR*	0.95 (0.53-1.73)	1	1.15 (0.81-1.61)	0.43
Multivariable HR**	0.95 (0.52-1.72)	1	1.17 (0.82-1.61)	0.42
Post-menopause				
Person-years	20,164	139,181	38,812	
No. of case	19	133	33	
Age, area-adjusted HR	0.98 (0.61-1.59)	1	0.90 (0.62-1.32)	0.70
Multivariable HR*	0.98 (0.61-1.59)	1	0.87 (0.59-1.29)	0.60
Multivariable HR**	0.98 (0.60-1.58)	1	0.88 (0.60-1.30)	0.64

HR, hazard ratio; 95% CI, 95% confidence interva; *Adjusted further for family history of breast cancer, alcohol intake, smoking status, age at menarche, age at first delivery, number of deliveries, menopausal status, age at menopause, use of post-menopausal; hormone, and leisure time physical activity; ** Adjusted further for body mass index.

temperature and the risk of breast cancer was not significant in overall, premenopausal, and postmenopausal women (Table 3). Compared to almost daily tub bathing with lukewarm or warm, no excess risk of breast cancer was observed for other combinations of the tub bathing frequency and bathing temperature (Table 4).

Discussion

This study is the first to explore the longitudinal association between tub bathing habits and the risk of developing breast cancer. In the present long-term cohort study, we found no associations between tub bathing frequency, subjective tub temperature, and their

Table 4. The Association between Tub Bathing Frequency and Cancer Risk by Bath Water Temperature

	Lukewarm or warm		Hot	
	Almost daily	≤4 days/week	Almost daily	≤4 days/week
Total participants				
Person-years	210,711	78,237	61,083	17,323
No. of cases	211	77	64	17
Multivariable HR*	1	1.16 (0.87-1.56)	1.06 (0.80-1.41)	1.09 (0.64-1.83)
Multivariable HR**	1	1.17 (0.88-1.57)	1.06 (0.80-1.41)	1.09 (0.65-1.84)
Pre-menopause				
Person-years	92,218	32,897	30,239	8,055
No. of cases	98	34	34	12
Multivariable HR*	1	1.07 (0.70-1.65)	1.07 (0.72-1.58)	1.61 (0.86-3.02)
Multivariable HR**	1	1.07 (0.70-1.64)	1.07 (0.73-1.59)	1.61 (0.86-3.02)
Post-menopause				
Person-years	115,942	43,404	29,948	8,865
No. of cases	112	40	28	5
Multivariable HR*	1	1.20 (0.80-1.80)	1.00 (0.66-1.52)	0.58 (0.21-1.59)
Multivariable HR**	1	1.24 (0.83-1.86)	1.01 (0.67-1.54)	0.60 (0.22-1.64)

HR, hazard ratio; 95% CI, 95% confidence interval; *Adjusted further for family history of breast cancer, body mass index, alcohol intake, smoking status, age at menarche; age at first delivery, number of deliveries, menopausal status, age at menopause, use of post-menopausal hormone; and leisure time physical activity; ** Adjusted further for body mass index.

combination with the risk of breast cancer among Japanese women.

Although we expected an inverse association between tub bathing and the risk of breast cancer, the lack of association could be due to the insufficient temperature rise and duration of tub bathing. Hyperthermia has a direct anti-tumor effect [22] and an indirect effect by activating natural killer cells [23]. A meta-analysis of five randomized clinical trials [15] and two separate trials [16, 17] of hyperthermia therapy have demonstrated the effectiveness of tumor control; the typical protocol for hyperthermia therapy in these trials is multiple sessions at the temperature of 43°C to 45°C for 60 minutes. It is uncertain, however, whether habitual tub bathing to exposed heat of 40-43℃ for 5 to 20 minutes in winter and slightly less duration at 38-42℃ in summer [24] could contribute to preventing the occurrence of breast cancer. According to a previous case-control study of Japanese aged 26-69 with 148 breast cancer cases and 296 age- and residence-matched controls, hot tub bathing was inversely but not significantly associated with the risk of breast cancer compared to lukewarm tub bathing among either premenopausal or postmenopausal women; the multivariable odds ratio was 0.92 (0.45-1.88), and 0.66 (0.33-1.34), respectively [25]. However, that study had a small sample size and did not examine the frequency of tub bathing.

The strengths of this study included its population-based prospective design and a high follow-up ratio, in which information was collected before the subsequent diagnosis of breast cancer, thereby avoiding the exposure recall bias inherent to case-control studies. Several limitations should be mentioned. First, the frequency and temperature of bathing were self-reported, and the data were obtained once at the baseline survey. Second, the information on the temperature of tub water with seasonal variations was not obtained. Third, the number of cases of post-menopausal breast cancer was small for statistical analysis. Fourth, residual confounding cannot be discarded. Lastly, the participants in this study were from Iwate, Akita, and Nagano public health center areas; thus, the generalizability of our findings to other areas is uncertain.

In conclusion, the present study showed no excess or reduced risk of breast cancer for women who bathed in tubs. Further research is needed to obtain objective information on the frequency, duration, and water temperature of tub bathing.

Author Contribution Statement

Naoya Teraoka constructed a study hypothesis, analyzed the data, and wrote the manuscript with the help of Isao Muraki and Hiroyasu Iso. All authors reviewed and revised the manuscript critically for important intellectual content and approved the final manuscript for submission.

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Funding statement

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Ethics approval and consent to participate

All JPHC Study participants were informed of the objectives of the study. Those who completed the survey questionnaire were regarded as consenting to participate in the study. The study protocol was approved by the Institutional Human Ethics Review Boards of the National Cancer Center (approval number: 2001-021, 2015-085) and Osaka University Hospital (approval number: 14285).

Availability of data and material

For information on data availability, refer to this link: https://epi.ncc.go.jp/en/jphc/805/8155.html

Conflict of interest

The authors declare that they have no conflict of interest.

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