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# Sauna bathing reduces the risk of stroke in Finnish men and women

## A prospective cohort study

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## Abstract

### Objective

To assess the association between frequency of sauna bathing and risk of future stroke.

### Methods

Baseline habits of sauna bathing were assessed in 1,628 adult men and women aged 53–74 years (mean age, 62.7 years) without a known history of stroke in the Finnish Kuopio Ischemic Heart Disease prospective cohort study. Three sauna bathing frequency groups were defined: 1, 2–3, and 4–7 sessions per week. Hazard ratios (HRs) (95% confidence intervals [CIs]) were estimated for incident stroke.

### Results

During a median follow-up of 14.9 years, 155 incident stroke events were recorded. Compared with participants who had one sauna bathing session per week, the age- and sex-adjusted HR (95% CI) for stroke was 0.39 (0.18–0.83) for participants who had 4–7 sauna sessions per week. After further adjustment for established cardiovascular risk factors and other potential confounders, the corresponding HR (95% CI) was 0.39 (0.18–0.84) and this remained persistent on additional adjustment for physical activity and socioeconomic status at 0.38 (0.18–0.81). The association between frequency of sauna bathing and risk of stroke was not modified by age, sex, or other clinical characteristics ( $p$  for interaction  $> 0.10$  for all subgroups). The association was similar for ischemic stroke but modest for hemorrhagic stroke, which could be attributed to the low event rate ( $n = 34$ ).

### Conclusions

This long-term follow-up study shows that middle-aged to elderly men and women who take frequent sauna baths have a substantially reduced risk of new-onset stroke.

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## Glossary

**BMI** = body mass index; **CHD** = coronary heart disease; **CI** = confidence interval; **CVD** = cardiovascular disease; **HR** = hazard ratio; **ICD-10** = International Classification of Diseases–10; **IQR** = interquartile range; **KIHD** = Kuopio Ischemic Heart Disease; **LDL-C** = low-density lipoprotein cholesterol; **SES** = socioeconomic status.

Sauna bathing is an activity that has been regarded as a tradition in Finland for thousands of years<sup>1</sup> and commonly used for relaxation and pleasure, and is now becoming increasingly popular in many other cultures.<sup>2,3</sup> Emerging evidence suggests that sauna bathing is linked to a reduced risk of cardiovascular outcomes such as hypertension,<sup>4</sup> cardiovascular disease (CVD) mortality,<sup>5</sup> and dementia,<sup>6</sup> as well as all-cause mortality.<sup>5</sup> Single or repeated regular sauna bathing sessions have been shown to have consequences on circulatory and cardiovascular function via reduction in blood pressure, positive modulation of lipid profiles, reduction in arterial stiffness and carotid intima media thickness, and decrease in peripheral vascular resistance.<sup>4,7–11</sup>

Stroke, which is the commonest form of CVD after coronary heart disease (CHD), is a global public health problem.<sup>12</sup> Given that CVD and stroke share common major risk factors such as blood pressure and the emerging evidence of a link between sauna bathing and reduced blood pressure and CVD risk,<sup>1,4,5</sup> we hypothesized that sauna bathing would be linked to the risk of stroke in the general population. However, the prospective association between sauna bathing habits and risk of stroke has not been investigated. In this context, based on a general population-based prospective cohort of middle-aged to elderly men and women recruited from Eastern Finland, we aimed to investigate and characterize the relationship between frequency of sauna bathing and the risk of incident stroke.

## Methods

### Study population

The study cohort was part of the Finnish Kuopio Ischemic Heart Disease (KIHD) risk factor study.<sup>5,13</sup> The KIHD study was initially based on a cohort of men aged 42–61 years who were living in Kuopio and the surrounding rural communities in the east of Finland. They were subsequently reexamined at 4, 11, and 20 years. Details of the study design and recruitment methods of this initial cohort have been described in previous reports.<sup>5,13,14</sup> At the 11-year follow-up examination, women were invited to join the study. This cohort, which is being utilized for the current analysis, comprised 2,358 participants (1,007 men and 1,351 women) who were aged 53–74 years and had their baseline examinations conducted from March 1998 to December 2001.<sup>15,16</sup> Of 2,072 participants who were found to be potentially eligible, 193 did not agree to participate, 66 did not respond to the invitation, and 39 declined to provide informed consent, which left 1,774 female and male participants for the current sauna prospective study.<sup>15,16</sup> Participants without information on assessment of sauna bathing habits at baseline examination ( $n = 31$ ) and

participants with a history of stroke ( $n = 64$ ) and with missing information on relevant covariates ( $n = 51$ ) were excluded. This analysis included 1,628 participants (840 women and 788 men) who had complete information on sauna bathing habits, relevant covariates, and incident stroke (appendix e-1, [links.lww.com/WNL/A487](https://links.lww.com/WNL/A487)). The research protocol was approved by the Research Ethics Committee of the University of Eastern Finland and every participant provided written informed consent. The study was performed in accordance with Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for reporting observational studies in epidemiology.<sup>17</sup>

### Assessment of sauna bathing

In a traditional Finnish sauna, the relative humidity of the air is between 10% and 20%. The temperature is much lower at the floor level, which ensures efficient ventilation and that the conditions are comfortable for sauna bathers.<sup>1</sup> Humidity can be temporarily increased by throwing water on the hot rocks of the sauna heater. Habits of sauna bathing were assessed by questionnaires that were self-administered and included assessment of the weekly frequency of sauna sessions, duration of sauna sessions, and temperature in the sauna room, as measured by a thermometer.<sup>5</sup> The questionnaire assessment represented average sauna bathing habits during the week. An experienced nurse cross-checked the questionnaires during baseline examinations.

### Assessment of risk markers

All baseline characteristics including cardiovascular risk markers were evaluated on the same day at study entry. Participants fasted overnight and abstained from drinking alcohol for at least 3 days and from smoking for at least 12 hours before blood collection. Total cholesterol, low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol were measured enzymatically (Boehringer Mannheim, Mannheim, Germany) from fresh serum samples after combined ultracentrifugation and precipitation.<sup>18</sup> Serum triglycerides were also measured enzymatically (Boehringer Mannheim). Fasting plasma glucose was estimated by the glucose dehydrogenase method (Merck, Darmstadt, Germany) after protein precipitation by trichloroacetic acid.<sup>18</sup> A random-zero sphygmomanometer (Hawksley, Sussex, UK) was used to measure resting blood pressure between 8 and 10 AM after 5 and 10 minutes of rest in a seated position.<sup>19</sup> Self-administered questionnaires were used to assess baseline sociodemographic and lifestyle characteristics, prevalent medical conditions, use of medication, physical activity levels, and socioeconomic status (SES).<sup>20</sup> The diagnosis of chronic medical conditions and use of medication were cross-checked

during a medical examination by a doctor. The energy expenditure of physical activity was assessed from a validated 12-month leisure-time physical activity questionnaire.<sup>21,22</sup> This detailed quantitative questionnaire deals with the most common leisure-time physical activities of middle-aged Finnish men. For the type of physical activity performed, participants were asked to document the frequency (number of sessions per month), average duration (hours and minutes per session), and intensity.<sup>23</sup> Energy expenditure was measured for each physical activity by multiplying the metabolic index of activity (in metabolic equivalent  $\times$  hour per week) by body weight in kilograms. The Nordic Alcohol Consumption Inventory was used to assess alcohol consumption. Body mass index (BMI) was calculated by dividing measured weight in kilograms by the square of height in meters.

### Ascertainment of stroke outcomes

The primary outcome was first-onset stroke events with subsidiary analyses of stroke subtypes (ischemic and hemorrhagic stroke) that were recorded from study enrollment through 2014. Participants are under continuous annual surveillance (using unique personal identification codes) for the occurrence of CVD outcomes, including stroke events. The KIHHD study has no losses to follow-up. Information on stroke outcomes was ascertained by computerized data linkage to the Finnish national hospital discharge registry and death certificate registers. Information on stroke diagnosis was collected from hospitals, medico-legal documents, and autopsy reports, and classification performed by a neurologist.<sup>24</sup> Stroke diagnosis was based on sudden onset of clinical signs or focal or global disturbance of cerebral function lasting  $>24$  hours (except in the case of sudden death or if interrupted by surgical intervention) with no apparent cause other than a vascular origin.<sup>25</sup> A suspected stroke event (ICD-10 codes I60–I68 and G45–G46) was classified into (1) a definite stroke, (2) no stroke, or (3) unclassifiable events. Each definite stroke was further classified into (1) an ischemic stroke (ICD-10 codes I63) or (2) a hemorrhagic stroke (ICD-10 codes I60 to I61).<sup>25</sup> If a participant had multiple nonfatal strokes during the follow-up, the first-onset stroke was considered as the end point. CT, MRI, and autopsies were performed in 100% of patients.<sup>25</sup>

### Statistical analysis

Baseline characteristics are presented as means (SD) or medians (interquartile range [IQR]) for continuous variables and percentages for categorical variables using descriptive analyses. Hazard ratios (HRs) with their 95% confidence intervals (CIs) for stroke were calculated using Cox proportional hazard models, after confirmation of no major departure from the proportionality of hazards assumptions.<sup>26</sup> Participants were categorized into 3 sauna bathing frequency groups (1, 2–3, and 4–7 sessions per week), to maintain consistency with previous reports.<sup>4–6</sup> In a subsidiary analysis, we categorized frequency of sauna bathing into 0–1, 2–3, and 4–7 times per week, to take into account participants who did not use sauna at all ( $n = 43$ ). HRs were progressively adjusted

for (1) age and sex (model 1); (2) BMI, smoking, systolic blood pressure (SBP), serum LDL-C, alcohol consumption, type 2 diabetes, use of hypertensive medication, use of aspirin, and use of lipid-lowering therapy (model 2); and (3) total duration of physical activity per week and SES (model 3). These covariates were selected based on (1) their established roles as cardiovascular risk factors, (2) research evidence, and (3) their role as potential confounders.<sup>27</sup> To assess if the relationship between frequency of sauna bathing and risk of stroke was modified by clinically relevant characteristics including age and sex, we performed subgroup analyses using interaction tests. Sensitivity analysis was conducted, which involved excluding the first 2 years of follow-up and participants with prevalent history of atrial fibrillation. A  $p$  value  $<0.05$  was considered statistically significant. Statistical analyses were performed using Stata version 12 (StataCorp, College Station, TX).

## Results

### Baseline characteristics

A summary of baseline characteristics of overall study participants and according to the group of weekly frequency of sauna bathing is shown in table 1. There were 840 (51.6%) female and 788 (48.4%) male participants. The mean (SD) age was 62.7 (6.5) years. The median (IQR) frequency and mean (SD) temperature of sauna bathing were 2 (1–3) times per week and 75.8 (9.9)  $^{\circ}\text{C}$ , respectively. Participants with the highest frequency of sauna bathing of 4–7 times per week were younger, more likely to be male, had higher BMI, and consumed more alcohol compared with the participants in the other groups.

### Sauna bathing and risk of stroke

During a median (IQR) follow-up of 14.9 (14.0–15.8) years, a total of 155 stroke events (60 in female and 95 in male participants) occurred. Stroke rates per 1,000 person-years of follow-up across the 3 frequency groups of sauna bathing (1, 2–3, and 4–7 times per week) were 8.1 (95% CI 6.1–10.8), 7.4 (95% CI 6.1–9.0), and 2.8 (95% CI 1.4–5.7), respectively. Cumulative hazard curves demonstrated a lower risk of stroke among participants who took 4–7 sauna bathing sessions per week compared with the other 2 groups ( $p = 0.014$  for log-rank test; figure 1). In analyses adjusted only for age and sex, when compared to participants who had 1 sauna session per week, the HR of stroke was 0.39 (95% CI 0.18–0.83) for participants who had 4–7 sauna sessions per week. After further adjustment for several established risk factors and other potential confounders (BMI, smoking, SBP, LDL-C, alcohol consumption, type 2 diabetes, and use of hypertensive medication, aspirin, and lipid-lowering therapy), the HR remained the same for 4–7 sauna bathing sessions per week (table 2). The HR remained consistent on additional adjustment for physical activity and SES. The association was unchanged on further adjustment for the temperature of sauna bathing, 0.38 (95% CI 0.17–0.81), or after taking into account

**Table 1** Baseline characteristics of overall study participants and according to frequency of sauna bathing

Characteristics	Overall (n = 1,628), mean (SD) or n (%)	Frequency of sauna bathing (times/wk), mean (SD) or n (%)			p Value for heterogeneity
		1 (n = 435)	2-3 (n = 996)	4-7 (n = 197)	
<b>Characteristics</b>					
Age, y	62.7 (6.5)	63.4 (6.5)	63.0 (6.4)	59.8 (6.1)	<0.0001
Male	788 (48.4)	169 (38.9)	494 (49.6)	125 (63.5)	<0.001
Body mass index, kg/m <sup>2</sup>	27.8 (4.4)	27.3 (4.4)	28.0 (4.4)	28.0 (4.5)	0.017
Waist-to-hip ratio	0.91 (0.09)	0.89 (0.09)	0.91 (0.09)	0.94 (0.08)	<0.0001
Cigarette smoking, pack-years <sup>a</sup>	3.13 (10.43)	3.92 (11.72)	2.96 (10.17)	2.22 (8.46)	0.119
Alcohol consumption, g/wk	49.4 (101.0)	45.8 (95.6)	46.4 (89.3)	72.2 (153.0)	0.003
Serum total cholesterol, mmol/L	5.48 (0.96)	5.46 (0.99)	5.49 (0.96)	5.48 (0.92)	0.816
Serum LDL-C, mmol/L	3.60 (0.93)	3.56 (0.94)	3.62 (0.93)	3.60 (0.85)	0.538
Serum HDL-C, mmol/L	1.25 (0.31)	1.26 (0.32)	1.24 (0.30)	1.26 (0.33)	0.545
Serum log <sub>e</sub> triglycerides, mmol/L	0.13 (0.46)	0.10 (0.48)	0.15 (0.45)	0.12 (0.46)	0.164
Systolic blood pressure, mm Hg	136 (17)	136 (18)	136 (17)	135 (17)	0.530
Diastolic blood pressure, mm Hg	81 (9)	81 (9)	81 (9)	82 (10)	0.326
Fasting blood glucose, mmol/L	5.08 (1.23)	5.10 (1.30)	5.08 (1.20)	5.06 (1.23)	0.943
Physical activity, kcal/d <sup>b</sup>	479 (402)	431 (404)	487 (375)	552 (506)	0.291
Socioeconomic status <sup>c</sup>	10.9 (4.7)	10.2 (4.7)	11.3 (4.7)	10.3 (4.5)	0.0002
<b>Clinical conditions and family histories</b>					
Smokers	217 (13.3)	70 (16.1)	128 (12.9)	19 (9.6)	0.068
Type 2 diabetes	132 (8.1)	42 (9.7)	77 (7.7)	13 (6.6)	0.335
Coronary heart disease	445 (27.3)	119 (27.4)	272 (27.3)	54 (27.4)	0.999
Atrial fibrillation	48 (3.0)	14 (3.2)	31 (3.1)	3 (1.5)	0.449
History of hypertension	667 (41.0)	181 (41.6)	406 (40.8)	80 (40.6)	0.950
Family history of hypertension	955 (58.7)	252 (57.9)	580 (58.2)	123 (62.4)	0.515
<b>Regular use of medications</b>					
Any antihypertensive medication	675 (41.5)	183 (42.1)	415 (41.7)	77 (39.1)	0.763
β-blockers	419 (25.7)	121 (27.8)	248 (24.9)	50 (25.4)	0.506
Diuretics	152 (9.3)	34 (7.8)	104 (10.4)	14 (7.1)	0.151
Calcium channel blockers	187 (11.5)	49 (11.3)	117 (11.8)	21 (10.7)	0.896
ACE inhibitors or AR blockers	231 (14.2)	58 (13.3)	145 (14.6)	28 (14.2)	0.830
Acetylsalicylic acid	372 (22.9)	104 (23.9)	226 (22.7)	42 (21.3)	0.759
Antithrombotic agent	316 (19.4)	85 (19.5)	196 (19.7)	35 (17.8)	0.822
Drug for high cholesterol	77 (4.7)	16 (3.7)	53 (5.3)	8 (4.1)	0.361

Abbreviations: ACE = angiotensin-converting enzyme; AR = angiotensin receptor; HDL-C = high-density lipoprotein cholesterol; LDL-C = low-density lipoprotein cholesterol.

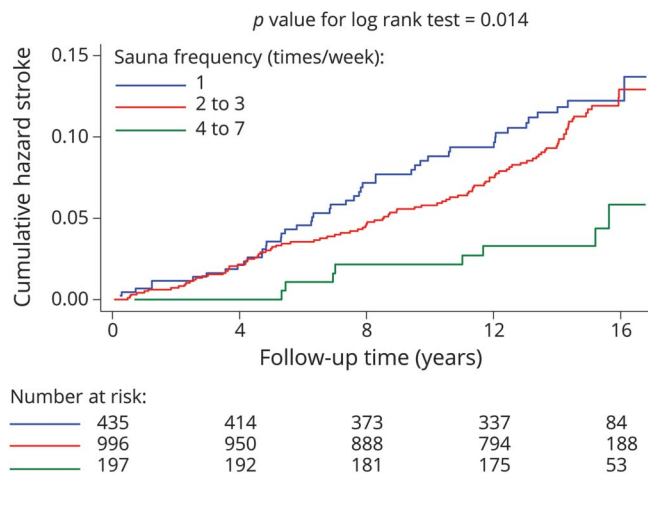
<sup>a</sup> Pack-years denotes the lifelong exposure to smoking, which was estimated as the product of years smoked and the number of tobacco products smoked daily at the time of examination.

<sup>b</sup> Physical activity was computed by multiplying the duration and intensity of each physical activity by body weight. Physical activity was assessed using the 12-month physical activity questionnaire.

<sup>c</sup> Socioeconomic status is a summary index that combine measures of income, education, occupation, occupational prestige, material standard of living, and housing conditions, all of which were assessed with self-reported questionnaires.



**Figure 1** Cumulative Kaplan-Meier curves for stroke during follow-up according to the frequency of sauna bathing per week



incident CHD as a time-varying covariate, 0.38 (95% CI 0.18–0.81). A total of 390 deaths (154 in female and 236 in male participants) occurred during follow-up. Analysis with death as a competing risk event yielded an HR of 0.43 (95% CI 0.17–1.10) for 4–7 sauna sessions per week. The association between frequency of sauna bathing and risk of stroke was not significantly modified by any clinically relevant characteristic (figure 2). The respective relationships remained consistent in Cox multivariable analysis that excluded the first 2 years of follow-up (appendix e-2, links.lww.com/WNL/A487) or participants with a history of atrial fibrillation (n = 48) at baseline (appendix e-3). In separate analyses for stroke subtypes, participants who had 4–7 sauna sessions per week had a significantly reduced risk of ischemic stroke (129 events, 48 in women and 81 in men) in analyses adjusted for several established risk factors and other potential confounders; however, for hemorrhagic stroke (34 events, 17 in women and 17 in men), the association was not significant (table 3). In a subsidiary analysis that compared 4–7 sauna sessions per week with 0–1 sauna session per week, the associations were similar (appendix e-4).

## Discussion

Based on a general population sample of men and women without a history of stroke at baseline, the current findings show that a higher frequency of sauna bathing is strongly, inversely, and independently associated with future risk of stroke events over a 15-year follow-up. The association was not modified by clinically relevant characteristics including age and sex. In analysis by stroke subtypes, weekly frequency of sauna bathing was also inversely and independently associated with ischemic stroke subtype. However, the association with hemorrhagic stroke was less robust, which could be attributed to the low event rate. Finally, the inverse independent association persisted in several sensitivity analyses.

We are unable to directly compare these findings with previous published work, as this is the first prospective study to demonstrate the association between sauna bathing frequency and stroke risk in the general population. However, our current results are consistent with that of our previous study in men, which showed strong inverse and independent associations of sauna bathing with risk of fatal cardiovascular and coronary outcomes as well as all-cause mortality.<sup>5</sup> Previous observational and interventional studies have also shown beneficial effects of heat or sauna therapy on blood pressure and other indices of cardiovascular function<sup>7–10,28,29</sup> that are involved in the pathophysiology of adverse cardiovascular outcomes. Recently, we have also shown that regular sauna bathing is associated with a reduced risk of future hypertension.<sup>4</sup> Given that stroke is the second common manifestation of CVD after CHD and these outcomes share common antecedent risk factors, the overall findings confirm a beneficial effect of regular sauna bathing on major cardiovascular outcomes. However, large-scale studies are needed to replicate the current findings, which suggest a protective effect of passive heat therapy exposure on stroke risk.

Mechanistic pathways postulated to underlie the beneficial effect of sauna bathing on cardiovascular outcomes may include reduction in systemic blood pressure,<sup>4,7,9</sup> stimulation of the immune system,<sup>30</sup> positive alteration of the autonomic nervous system,<sup>8</sup> positive effects on circulating lipid profiles,<sup>11</sup> and reduction in oxidative stress,<sup>8,31</sup> arterial stiffness, carotid

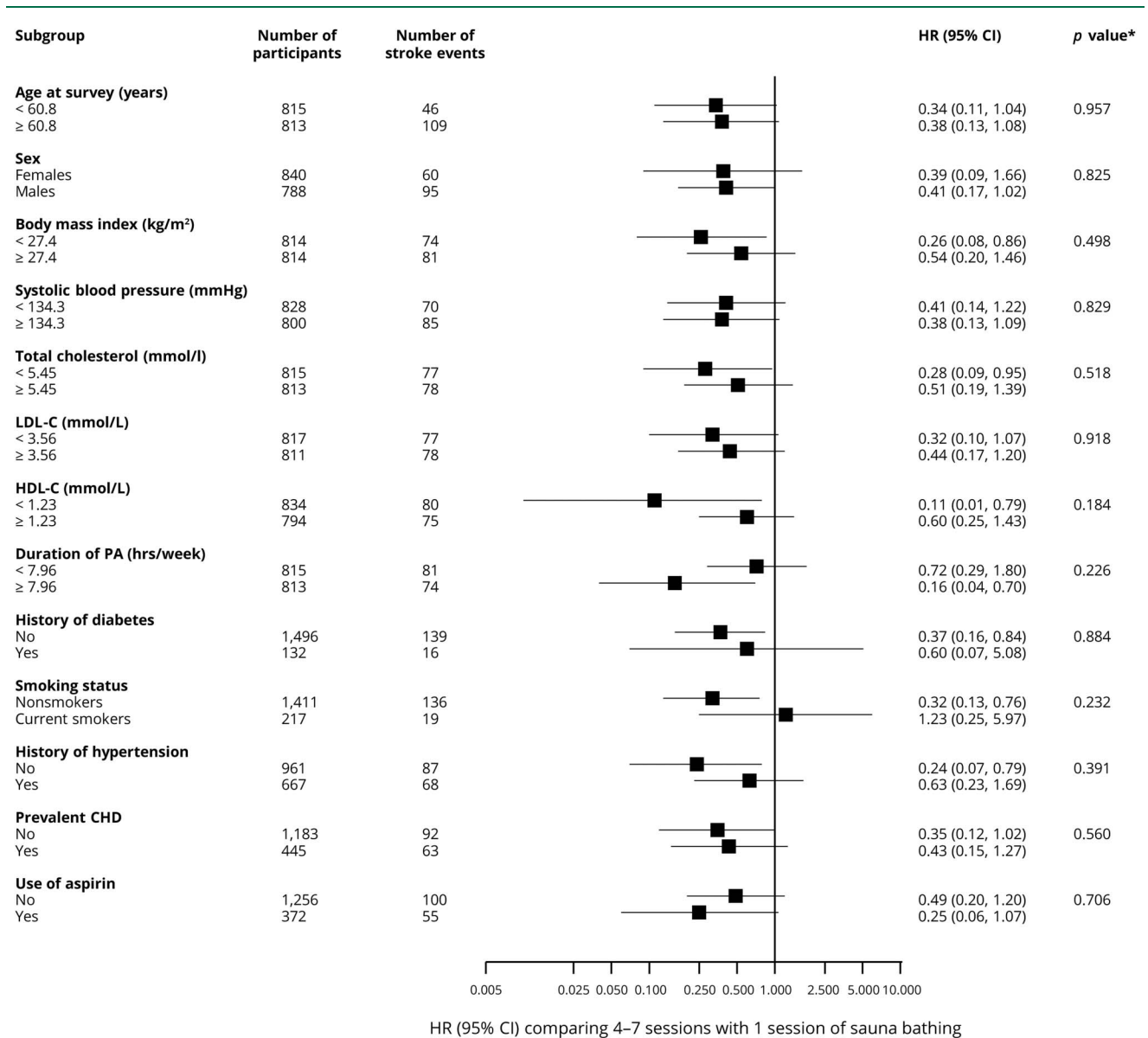
**Table 2** Hazard ratios (HRs) of stroke according to the frequency of sauna bathing

Frequency of sauna bathing (times/wk), once	Model 1 (reference), HR (95% CI)	p Value	Model 2 (reference), HR (95% CI)	p Value	Model 3 (reference), HR (95% CI)	p Value
2–3	0.86 (0.61–1.22)	0.399	0.90 (0.64–1.29)	0.577	0.88 (0.61–1.25)	0.471
4–7	0.39 (0.18–0.83)	0.014	0.39 (0.18–0.84)	0.016	0.38 (0.18–0.81)	0.013
<b>p Value for trend</b>		0.025		0.039		0.028

Abbreviation: CI = confidence interval.

Analysis is based on 1,628 participants and 155 strokes; reference is reference comparison for exposure. Model 1: Adjusted for age and sex. Model 2: Model 1 plus body mass index, smoking, systolic blood pressure, serum low-density lipoprotein cholesterol, alcohol consumption, type 2 diabetes, use of hypertensive medication, use of aspirin, and use of lipid-lowering therapy. Model 3: Model 2 plus physical activity (duration per week) and socioeconomic status.

**Figure 2** Association of frequency of sauna bathing with stroke in clinically relevant subgroups



Hazard ratios (HRs) are adjusted for age, sex, body mass index, smoking, systolic blood pressure, serum low-density lipoprotein cholesterol (LDL-C), alcohol consumption, type 2 diabetes, use of hypertensive medication, use of aspirin, and use of lipid-lowering therapy; HRs are reported comparing 4–7 sauna sessions per week with 1 sauna session per week. \*p Value for interaction; cutoffs used for age, body mass index, systolic blood pressure, total cholesterol, LDL-C, high-density lipoprotein cholesterol (HDL-C), and duration of physical activity (PA) are median values. CHD = coronary heart disease; CI = confidence interval.

intima media thickness, and peripheral vascular resistance.<sup>7–10</sup> We postulate that these same pathways are likely to underpin the association between sauna bathing and reduced stroke incidence. There is an established body of evidence that shows that the majority of the stroke burden can be attributable to suboptimal blood pressure and that the risk of stroke is considerably lowered with blood pressure lowering.<sup>32</sup> With the accumulating evidence of a blood pressure lowering effect of passive heat therapy or sauna bathing,<sup>1,4,7</sup> this pathway may potentially underlie the beneficial effect of sauna bathing on stroke risk. We have also recently shown that sauna bathing is associated with lowered risks of dementia and Alzheimer

disease.<sup>6</sup> The protective effect of sauna bathing on stroke risk may underpin the inverse association demonstrated between sauna bathing and these memory diseases, given that some of these neurocognitive diseases have a vascular aetiology.<sup>33,34</sup> Further studies are warranted to unravel if other pathways such as modulation of levels in circulating cardiovascular biomarkers are involved in the relationship between sauna bathing and reduced stroke risk.

Our findings highlight a protective effect of regular and frequent sauna bathing on the long-term risk of stroke. Taken together, the consistent overall observational evidence of

**Table 3** Hazard ratios (HRs) of stroke subtypes according to the frequency of sauna bathing

Frequency of sauna bathing (times/wk), once	Model 1 (reference), HR (95% CI)	p Value	Model 2 (reference), HR (95% CI)	p Value	Model 3 (reference), HR (95% CI)	p Value
<b>Ischemic stroke</b>						
2-3	0.90 (0.61-1.32)	0.577	0.95 (0.64-1.40)	0.779	0.91 (0.61-1.35)	0.634
4-7	0.43 (0.19-0.98)	0.044	0.43 (0.19-0.99)	0.047	0.42 (0.18-0.96)	0.039
<b>p Value for trend</b>		0.079		0.110		0.080
<b>Hemorrhagic stroke</b>						
2-3	0.69 (0.34-1.42)	0.316	0.73 (0.35-1.51)	0.394	0.71 (0.34-1.47)	0.357
4-7	0.32 (0.07-1.47)	0.144	0.35 (0.08-1.61)	0.177	0.33 (0.07-1.51)	0.152
<b>p Value for trend</b>		0.109		0.152		0.126

Abbreviation: CI = confidence interval.

For ischemic stroke, analysis is based on 1,628 participants and 129 cases and for hemorrhagic stroke, analysis is based on 1,628 participants and 34 cases; reference is reference comparison for exposure. Model 1: Adjusted for age and sex. Model 2: Model 1 plus body mass index, smoking, systolic blood pressure, serum low-density lipoprotein cholesterol, alcohol consumption, type 2 diabetes, use of hypertensive medication, use of aspirin, and use of lipid-lowering therapy. Model 3: Model 2 plus physical activity (duration per week) and socioeconomic status.

a continuous and independent association between the frequency of sauna bathing and cardiovascular risk along with previous experimental evidence<sup>1</sup> may suggest a causal relationship; however, this will require robust evidence from randomized controlled trials. In the absence of such trials, regular sauna bathing is a recommendable habit as it is a well-tolerated and safe activity for most healthy people as well as patients with stable cardiac disease.<sup>1</sup> However, there are some contraindications to sauna bathing, and these include recent myocardial infarction, unstable angina pectoris, or severe aortic stenosis.<sup>1</sup> Elderly people prone to low blood pressure are also advised to exercise caution when using the sauna.<sup>1</sup> There have been some single case reports of sauna-related stroke and sudden cardiac death, but these have been attributed to hypotension, dehydration, or alcohol consumption during sauna bathing.<sup>35,36</sup> Sauna bathing, which is considered to be part of a relaxing lifestyle, has been shown to produce changes<sup>7,8,28,29</sup> at par with the physiologic adaptations associated with physical exercise without active skeletal muscle work.<sup>29</sup> A typical Finnish sauna may also positively modulate the autonomic nervous system,<sup>1</sup> which may partly explain the reductions in risk of hypertension<sup>4</sup> and stroke. Apart from its cardiovascular and neurocognitive benefits,<sup>6</sup> sauna bathing improves the pain and symptoms associated with rheumatic diseases,<sup>37</sup> ameliorates skin diseases such as psoriasis and urticaria,<sup>38</sup> and reduces the risk of lung disease.<sup>39,40</sup>

Our study has several notable strengths that deserve consideration. We have conducted the first long-term prospective evaluation of the association of frequency of Finnish sauna bathing with the risk of stroke in a general population-based cohort of men and women. This cohort was well-characterized, involved a long-term follow-up with participants continuously monitored using well-linked databases of incident stroke events, and there were no losses to follow-up. The analyses were robust as they included adjustment for

several lifestyle and biological markers, assessment of effect modification, and sensitivity analyses. There were a number of limitations: (1) the current findings are based on typical Finnish sauna baths and cannot be applied to other forms of passive heat therapy such as infrared heat exposure, steam rooms, Waon therapy, and hot tubs that are used in other settings, as these may operate at lower temperatures and do not mimic the traditional Finnish sauna conditions; (2) being an observational study, there was a potential for residual confounding caused by some unmeasured confounders and errors in measured confounders; (3) there was also a potential for reverse causation, but this was minimized as the cohort was based in a general population, participants with a history of stroke were excluded at baseline, and sensitivity analysis excluding the first 2 years of follow-up as well as participants with a history of atrial fibrillation yielded consistent results; (4) regression dilution could not be corrected for because we only had a one-time questionnaire-based assessment of sauna bathing during a typical week; (5) there is a possibility that sauna bathing habits may have changed during follow-up due to possible changes in health habits or other diseases; (6) our analysis on hemorrhagic stroke subtypes was limited because of the low event rate; and (7) only a few people did not use sauna baths at all and therefore we were unable to assess the association using this group as a reference comparison. Indeed, sauna bathing is a Finnish tradition and the greater majority of the population has the opportunity to have a sauna bath at least once a week. However, the associations were unchanged in a subsidiary analysis where a combination of people who did not use sauna baths and those who had a single sauna session per week was used as a reference comparison.

Overall, the results of this study demonstrate that frequent sauna bathing is associated with a reduced risk of future stroke in middle-aged to elderly Caucasian men and women. The



association was robust for ischemic stroke subtype but modest for hemorrhagic stroke, which is likely to be due to the low event rate for this stroke subtype. The present study adds to emerging evidence that passive heat therapy such as sauna bathing could improve cardiovascular health and decrease the risk of vascular events. Further studies in other populations are needed to investigate a potential protective role of sauna bathing in the prevention of cerebrovascular events and to evaluate the mechanistic pathways underlying the relationship between sauna exposure and stroke risk.

### Author contributions

S.K.K., H.K., F.Z., T.L., P.W., and J.A.L. conceived and designed the study. T.L. and J.A.L. acquired data. S.K.K. performed statistical analyses, interpreted data, and drafted the initial manuscript. S.K.K., H.K., F.Z., T.L., P.W., and J.A.L. performed further drafts and critically revised the manuscript for important intellectual content. J.A.L. supervised the study.

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### Disclosure

The authors report no disclosures relevant to the manuscript. Go to [Neurology.org/N](http://Neurology.org/N) for full disclosures.

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# Sauna bathing reduces the risk of stroke in Finnish men and women

## A prospective cohort study

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### Study question

Is the frequency of sauna bathing associated with the future risk of stroke?

### Summary answer

Among middle-aged and elderly people, frequent sauna bathing is associated with a substantially reduced risk of new-onset stroke.

### What is known and what this paper adds

Sauna bathing is associated with a reduced risk of cardiovascular disease. This study shows that it is also associated with a reduced risk of stroke, which shares major risk factors with cardiovascular disease.

### Participants and setting

This study examined 1,628 participants (840 women and 788 men; mean baseline age, 62.7 ± 6.5 years) from Kuopio and the surrounding rural communities in eastern Finland. The baseline examinations, at which point the participants had no history of stroke, were conducted from March 1998 to December 2001.

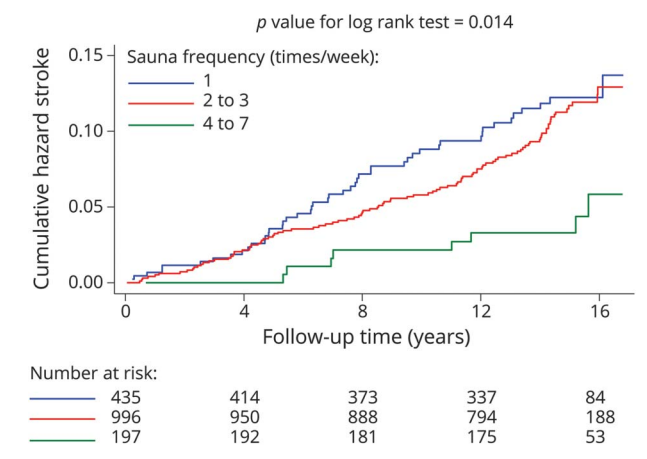
### Design, size, and duration

During baseline examinations, the participants completed questionnaires that assessed the weekly frequency of sauna bathing, sauna session durations, and sauna room temperatures. Additional questionnaires assessed sociodemographic characteristics, medical conditions, medications taken, and physical activity levels. The baseline examinations included assessments of cardiovascular risk markers including cholesterol levels, serum triglycerides, fasting plasma glucose, and resting blood pressure. Stroke events were detected by monitoring the Finnish national hospital discharge registry and death certificate registers.

### Main results and the role of chance

Over a median follow-up period of 14.9 years, 155 incident stroke events were detected. Relative to participants who reported 1 sauna bathing session per week, participants who reported 4–7 sessions per week had an age- and sex-adjusted hazard ratio for stroke of 0.39 (95% confidence interval, 0.18–0.83). Further adjustments for cardiovascular risk

**Figure** Cumulative Kaplan-Meier curves for stroke during follow-up according to weekly sauna bathing frequencies



factors, physical activity levels, socioeconomic status, and other potential confounders reduced the hazard ratio to 0.38 (95% confidence interval, 0.18–0.81).

### Bias, confounding, and other reasons for caution

This study might not have accounted for all potential confounders and could not account for regression dilution. Sauna bathing habits might have changed over the follow-up period. The number of participants reporting no sauna usage was too small for them to be used as a reference group.

### Generalizability to other populations

This study was based on the traditional Finnish sauna, so the results may not be generalizable to passive heat exposure practices found in other cultures.

### Study funding/potential competing interests

This study was funded by the Finnish Foundation for Cardiovascular Research. The authors report no competing interests. Go to [Neurology.org/N](http://Neurology.org/N) for full disclosures.

A draft of the short-form article was written by M. Dalefield, a writer with Editage, a division of Cactus Communications. The authors of the full-length article and the journal editors edited and approved the final version.

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## Sauna bathing reduces the risk of stroke in Finnish men and women: A prospective cohort study

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