Kunutsor, S. K., Laukkanen, T., & Laukkanen, J. A. (2017). Sauna bathing reduces the risk of respiratory diseases: a long-term prospective cohort study. *European Journal of Epidemiology*. Advance online publication. https://doi.org/10.1007/s10654-017-0311-6

Sauna bathing reduces the risk of respiratory diseases: a long-term prospective cohort study

Setor K. Kunutsor[1], Tanjaniina Laukkanen[2], Jari A. Laukkanen [2,3]

[1]School of Clinical Sciences, University of Bristol, Learning & Research Building (Level 1), Southmead Hospital, Southmead Road, Bristol, UK

[2]Institute of Public Health and Clinical Nutrition, University of Eastern Finland, Kuopio, Finland

[3]Central Finland Central Hospital, Jyväskylä, Finland

Corresponding author:

School of Clinical Sciences, University of Bristol, Learning & Research Building (Level 1), Southmead Hospital, Southmead Road, Bristol, BS10 5NB, UK. Phone: +44-7539589186; Fax: +44-1174147924; Email address: skk31@cantab.net

Word count [1,821]

Number of references [16]

Number of tables [2]

Abstract

Sauna bathing has been linked with numerous health benefits. Sauna bathing may reduce the risk of respiratory diseases; however, no prospective evidence exists to support this hypothesis. We aimed to assess the association of frequency of sauna bathing with risk of respiratory diseases (defined as chronic obstructive pulmonary disease, asthma, or pneumonia). Baseline sauna bathing habits were assessed in a prospective cohort of 1,935 Caucasian men aged 42-61 years. During a median follow-up of 25.6 years, 379 hospital diagnosed incident cases of respiratory diseases were recorded. In adjustment for several major risk factors for respiratory conditions and other potential confounders, the hazard ratios (HRs) 95% confidence intervals (CIs) of respiratory diseases were 0.73 (0.58-0.92) and 0.59 (0.37-0.94) for participants who had 2-3 and ≥ 4 sauna sessions per week respectively compared with participants who had ≤ 1 sauna session per week. The multivariate adjusted HR (95% CI) for pneumonia was 0.72 (0.57-0.90) and 0.63 (0.39-1.00) for participants who had 2-3 and ≥ 4 sauna sessions per week respectively. Frequent sauna baths may be associated with a reduced risk of acute and chronic respiratory conditions in a middle-aged male Caucasian population.

Keywords: Sauna; respiratory disease; pneumonia; chronic obstructive pulmonary disease; asthma; cohort study

Introduction

Sauna bathing has for thousands of years been regarded as a traditional activity in Finland and mainly used for pleasure and relaxation. The use of sauna is increasingly becoming common in many other countries.(1) Sauna bathing has been linked with many health benefits and these include improvement in the pain and symptoms associated with musculoskeletal diseases;(2) treatment of chronic headache; (3) and amelioration of skin diseases such as psoriasis and urticaria.(4) Recent emerging evidence also suggests that sauna bathing is associated with lowered risks of cardiovascular disease (CVD),(5) neurocognitive disease,(6) and all-cause mortality.(5) Chronic obstructive pulmonary disease (COPD), pneumonia, and asthma are debilitating respiratory diseases, which are commonly characterized by chest symptoms such as pain and tightness, cough, and shortness of breath. Chronic obstructive pulmonary disease is a progressive obstructive lung disease and has recently been named as the third leading cause of mortality globally.(7) Asthma is a long-term inflammatory disease of the airways of the lungs and causes about 250,000 to 345,000 deaths per year globally.(8) Pneumonia is a common inflammatory condition, which primarily affects the alveoli of the lungs and is responsible for considerable morbidity and as well as mortality.(9) These common respiratory diseases are disabling conditions which are associated with reduced quality of life and high economic costs.(10) Majority of cases of these respiratory conditions can be prevented through decreased exposure to their underlying risk factors which commonly include smoking, exposure to pollution and environmental chemicals, and coexisting comorbidities diseases such as diabetes.(10).

In addition to the accumulating beneficial effects of sauna bathing on several vascular and non-vascular outcomes, sauna bathing has also been suggested to improve lung function and the symptoms of lung disease.(11) Waon therapy, which is also a form of heat therapy, has been suggested to improve airway obstruction in patients with COPD.(12) Given the overall evidence, we hypothesized that sauna bathing may be linked to lowered risk of respiratory diseases. In this context, our aim was to evaluate the prospective association between frequency of sauna bathing and the risk of respiratory diseases (as

defined as COPD, asthma, or pneumonia), using a population-based prospective cohort study which comprised of 1,935 Caucasian men, who were apparently free from any respiratory diseases at baseline.

Methods

Participants in the study were men aged 42-61 years recruited into the Kuopio Ischemic Heart Disease (KIHD) study in eastern Finland, which has been described in detail previously.(5, 6) Briefly, subjects were a randomly selected sample of 3,433 men who resided in the town of Kuopio or its surrounding rural communities. Of those invited, 2,682 volunteered to participate in the study and those with complete information on sauna bathing were included (N=2,327). There were only 12 men who did not use sauna and were excluded from the analysis. Baseline sauna bathing were assessed by a self-administrated questionnaire which included assessment of the weekly frequency and duration of sauna sessions, as well as the temperature of the sauna bath. The assessment represented an average sauna use during the week. The questionnaires were cross-checked by an experienced nurse at the time of baseline examination.(5, 6) Baseline examinations were conducted between March 1984 and December 1989. Collection of blood specimens and measurements of relevant covariates have been described previously.(5, 6) Briefly, participants fasted overnight, were instructed to abstain from drinking alcohol for at least 3 days, and refrain from smoking for at least 12 h prior to assessment. Baseline demographics, lifestyle characteristics, prevalent diseases, the level of physical activity, and socioeconomic status (SES) were assessed by self-administered questionnaires.(5, 6) In the KIHD study, participants are under annual continuous monitoring for deaths and incident outcomes including respiratory diseases using unique personal identification numbers (PINs). All incident respiratory diseases diseases (defined as COPD, asthma, or pneumonia) that occurred from study entry to 2014 were included and these were collected by automatic record linkage to the National Hospital Discharge Register, which covers every hospitalization in Finland. The diagnosis of respiratory diseases was coded according to the International Classification of Diseases codes. An independent committee of physicians reviewed all potential cases to obtain a

consensus on the diagnosis and etiology. For the current analysis, all men with respiratory diseases (chronic bronchitis, asthma, or tuberculosis) at study entry (n=344) were excluded, leaving 1,935 men at baseline for the current analysis. The ethical committee of the University of Eastern Finland approved the study protocol. Hazard ratios (HRs) with 95% confidence intervals (CIs) were estimated using Cox proportional hazard models, after confirmation of the assumptions of the proportionality of hazards. Follow-up time was calculated from date of study entry to date of outcome diagnosis or end of follow-up. Participants were classified into three groups based on the frequency of sauna bathing (≤1, 2-3 and ≥ 4 times per week).(5, 6) All statistical analyses were conducted using Stata version 14 (Stata Corp, College Station, Texas).

Results

The overall mean [standard deviation (SD)] age and BMI of study participants at baseline were 53 (5) years and 27 (4) kg/m^2 respectively. The median (interquartile range) frequency and mean (SD) duration of sauna bathing was 2 (1-3) times per week and 14.0 (7.2) minutes per sauna bath (**Table 1**). During a median (interquartile range) follow-up of 25.6 (17.2-27.7) years, a total of 379 hospital diagnosed incident respiratory diseases were recorded (incidence rate of 8.92 per 1000 person-years at risk; 95% CI 8.06 to 9.87). In analyses adjusted only for age, when compared to participants who had ≤ 1 sauna session per week, the HRs of respiratory diseases were 0.66 (95% CI: 0.53 to 0.82) and 0.49 (95% CI: 0.31 to 0.77) for participants who had 2-3 and ≥ 4 sauna sessions per week respectively. After further adjustment for several risk factors (body mass index, smoking status, histories of diabetes and coronary heart disease, years of education, and alcohol consumption), the respective HRs were minimally attenuated to 0.68 (95% CI: 0.55 to 0.86) and for 0.53 (95% CI: 0.34 to 0.84). The significant association persisted on additional adjustment for total energy intake, SES, physical activity, and C-reactive protein, 0.73 (95% CI: 0.58 to 0.92) and 0.59 (95% CI: 0.37 to 0.94) for 2-3 and ≥ 4 sauna sessions per week respectively (**Table 2**). In analysis that further adjusted for duration and temperature of sauna baths, the HRs were

0.74 (95% CI: 0.58 to 0.93) and 0.61 (95% CI: 0.38 to 0.98) for 2-3 and ≥ 4 sauna sessions per week respectively. A total of 919 deaths occurred during follow-up. Analysis with death as a competing risk event yielded HRs of 0.87 (95% CI: 0.57 to 1.34) and 1.00 (95% CI: 0.50 to 1.98) for 2-3 and ≥ 4 sauna sessions per week respectively. In a test of interaction, the association of frequency of sauna bathing with risk of respiratory diseases was not modified by smoking (current smokers versus others) (*p*-value for interaction = 0.119). In a subsidiary analysis with pneumonia as a separate outcome, the multivariate HRs of pneumonia were 0.72 (95% CI: 0.57 to 0.90) and 0.63 (95% CI: 0.39 to 1.00) for participants who had 2-3 and ≥ 4 sauna sessions per week respectively. There was no evidence of an independent association between duration of a single sauna bathing session and risk of respiratory diseases.

Comment

Based on a population-based prospective cohort of middle-aged Caucasian men who had no apparent pre-existing respiratory diseases at baseline, we have found out that frequency of sauna bathing is inversely associated with future risk of respiratory diseases in a graded fashion. The association remained robust after adjustment for several risk factors for these respiratory conditions, as well as the duration and temperature of sauna baths. However, given the high mortality rate in our study cohort which might have hindered our event of interest, the association between frequency of sauna bathing and respiratory diseases was attenuated when death was modelled as a competing risk event. The association between frequency of sauna bathing and respiratory diseases was not modified by smoking status. A subsidiary analysis showed frequency of sauna bathing to be inversely associated with the risk of pneumonia.

Inflammatory processes are well known to be involved in the pathogenesis of these respiratory conditions,(10, 13) though their etiopathogenesis involves an interaction of both genetic and environmental factors. Accumulating evidence also shows that oxidative stress and damage play a pivotal role in the pathogenesis of these respiratory conditions.(14) The ability of sauna baths to decrease the risk of respiratory diseases may be explained via its ability to reduce oxidative stress.(15) The heat associated

with sauna baths may also have direct effects on the lung tissue by reducing pulmonary congestion and increasing tidal volume, vital capacity, ventilation, and forced expiratory volume of the lungs.(11) The current findings add to the accumulating knowledge on the beneficial effects of sauna baths on both acute and chronic health conditions. Sauna bathing is an enjoyable and relaxing activity, has a good safety profile, and well-tolerated by most people.(5, 6) Dry sauna bathing seems to be safe even among patients who have recovered from myocardial infarction (MI) and patients with stable angina pectoris or heart failure can enjoy sauna baths without any significant adverse cardiovascular effects. However, individuals who are prone to orthostatic hypotension, unstable angina pectoris, recent MI or severe aortic stenosis should exercise caution while using the sauna.(16) Though the public health implications of the current findings may seem limited in populations where sauna use is not common; it is expected that sauna bathing as a recreational activity will increase globally given the emerging evidence on its potential health benefits. Well designed trials are needed to evaluate the therapeutic implications of sauna bathing on pulmonary conditions and explore the mechanistic pathways underlying the associations.

This is the first prospective evaluation of the association between frequency of sauna bathing and risk of respiratory diseases in a general population-based sample of men who were free of any respiratory diseases at study entry. There were no losses to follow-up and the analysis adjusted for a comprehensive panel of several risk factors for respiratory diseases. The limitations of the current study include the limited data on specific respiratory conditions such as COPD and asthma which precluded the ability to assess the associations with these outcomes separately, the inability to generalize the findings to women and other populations, and the inability to correct for regression dilution bias which may have underestimated the associations demonstrated, as we only had a one-time questionnaire-based assessment of sauna bathing habits during a typical week. Sauna bathing habits may have changed during follow-up due to probable changes in health habits or other diseases; however, sauna bathing is a traditional Finnish habit and the greater majority of people have regular sauna baths irrespective of their age.

In conclusion, higher frequency of sauna bathing may be associated with a decreased risk of acute and chronic respiratory diseases in middle-aged Caucasian men. Further research is needed to replicate these findings and explore the biological processes underlying the relationship.

Acknowledgments

We thank the staff of the Kuopio Research Institute of Exercise Medicine and the Research Institute of Public Health and University of Eastern Finland, Kuopio, Finland for the data collection in the study.

Funding

This work was supported by the Finnish Foundation for Cardiovascular Research, Helsinki, Finland. These sources had no role in design and conduct of the study; collection, management, analysis, and interpretation of the data; and preparation, review, or approval of the manuscript.

Conflict of interest

The authors declare they have no conflict of interest.

References

1. Valtakari P. The sauna and bathing in different countries. Ann Clin Res. 1988;20(4):230-5.

2. Nurmikko T, Hietaharju A. Effect of exposure to sauna heat on neuropathic and rheumatoid pain. Pain. 1992;49(1):43-51.

3. Kanji G, Weatherall M, Peter R, Purdie G, Page R. Efficacy of regular sauna bathing for chronic tension-type headache: a randomized controlled study. J Altern Complement Med. 2015;21(2):103-9. doi:10.1089/acm.2013.0466

4. Hannuksela M, Vaananen A. The sauna, skin and skin diseases. Ann Clin Res. 1988;20(4):276-8.

5. Laukkanen T, Khan H, Zaccardi F, Laukkanen JA. Association between sauna bathing and fatal cardiovascular and all-cause mortality events. JAMA internal medicine. 2015;175(4):542-8. doi:10.1001/jamainternmed.2014.8187

6. Laukkanen T, Kunutsor S, Kauhanen J, Laukkanen JA. Sauna bathing is inversely associated with dementia and Alzheimer's disease in middle-aged Finnish men. Age Ageing. 2016. doi:10.1093/ageing/afw212

7. Kukkonen-Harjula K, Kauppinen K. Health effects and risks of sauna bathing. Int J Circumpolar Health. 2006;65(3):195-205.

8. Lozano R, Naghavi M, Foreman K, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 2012;380(9859):2095-128. doi:10.1016/S0140-6736(12)61728-0

9. Ruuskanen O, Lahti E, Jennings LC, Murdoch DR. Viral pneumonia. Lancet. 2011;377(9773):1264-75. doi:10.1016/S0140-6736(10)61459-6

10. Vestbo J, Hurd SS, Agusti AG, et al. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: GOLD executive summary. Am J Respir Crit Care Med. 2013;187(4):347-65. doi:10.1164/rccm.201204-0596PP

11. Laitinen LA, Lindqvist A, Heino M. Lungs and ventilation in sauna. Ann Clin Res. 1988;20(4):244-8.

12. Kikuchi H, Shiozawa N, Takata S, Ashida K, Mitsunobu F. Effect of repeated Waon therapy on exercise tolerance and pulmonary function in patients with chronic obstructive pulmonary disease: a pilot controlled clinical trial. Int J Chron Obstruct Pulmon Dis. 2014;9:9-15. doi:10.2147/COPD.S50860

13. Monton C, Torres A. Lung inflammatory response in pneumonia. Monaldi Arch Chest Dis. 1998;53(1):56-63.

14. Anderson D, Macnee W. Targeted treatment in COPD: a multi-system approach for a multi-system disease. Int J Chron Obstruct Pulmon Dis. 2009;4:321-35.

15. Sutkowy P, Woźniak A, Boraczyński T, Mila-Kierzenkowska C, Boraczyński M. The effect of a single Finnish sauna bath after aerobic exercise on the oxidative status in healthy men. Scand J Clin Lab Invest. 2014;74(2):89-94. doi:10.3109/00365513.2013.860616

16. Hannuksela ML, Ellahham S. Benefits and risks of sauna bathing. Am J Med. 2001;110(2):118-26.

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

	Frequency of sauna bathing (times/week)				
	Overall N=1,935	**1 N=501**	**2-3 N=1,262**	**≥ 4 N=172**	
Characteristic, unit	**Mean (SD) or median (interquartile range) or n (%)**	**Mean (SD) or median (interquartile range) or n (%)**	**Mean (SD) or median (interquartile range) or n (%)**	**Mean (SD) or median (interquartile range) or n (%)**	***p*-value for heterogeneity**
Questionnaire/prevalent conditions					
Age at survey (years)	53.0 (5.2)	53.3 (5.1)	53.1 (5.1)	51.1 (5.8)	< 0.0001
Alcohol consumption (g/week)	73.9 (127.2)	86.4 (161.4)	65.4 (102.1)	99.5 (168.1)	0.0002
Duration of sauna bathing (mins)	14.0 (7.2)	13.6 (7.4)	14.2 (7.0)	13.5 (8.0)	0.172
Temperature of sauna (° C)	79.0 (9.2)	80.6 (10.5)	78.5 (8.7)	77.5 (8.9)	< 0.0001
Years of education	8.7 (3.5)	9.0 (3.7)	8.6 (3.5)	8.8 (3.2)	0.065
History of diabetes	73 (3.8)	28 (5.6)	43 (3.4)	2 (1.2)	0.016
Current smokers	599 (31.0)	188 (37.5)	380 (30.1)	31 (18.0)	< 0.001
History of CHD	436 (22.5)	123 (24.6)	285 (22.6)	28 (16.3)	0.081
Physical measurements					
BMI (kg/m^2)	26.8 (3.5)	26.9 (3.6)	26.7 (3.4)	27.7 (4.2)	0.001
SBP (mmHg)	134 (17)	135 (18)	133 (16)	136 (17)	0.058
DBP (mmHg)	89 (10)	89 (11)	88 (10)	90 (12)	0.261
Physical activity (kj/day)	1,560 (1,409)	1,432 (1,382)	1,561 (1,301)	1,930 (2,057)	0.0003
Total energy intake (kj/day)	9,840 (2,557)	9,461 (2,510)	9,909 (2,566)	10,434 (2,478)	< 0.0001
Socio-economic status	8.27 (4.22)	8.64 (4.31)	8.22 (4.16)	7.56 (4.33)	0.012
Lipid, metabolic, and inflammatory markers					
Total cholesterol (mmol/l)	5.91 (1.07)	5.88 (1.10)	5.94 (1.07)	5.79 (0.99)	0.170
HDL-C (mmol/l)	1.30 (0.30)	1.26 (0.29)	1.30 (0.31)	1.33 (0.30)	0.016
Triglycerides (mmol/l)	1.11 (0.81-1.57)	1.15 (0.80-1.59)	1.10 (0.81-1.56)	1.11 (0.81-1.56)	0.783
Fasting plasma glucose (mmol/l)	5.34 (1.25)	5.51 (1.64)	5.27 (1.06)	5.31 (1.13)	0.001
C-reactive protein (mg/l)	1.23 (0.68-2.35)	1.45 (0.71-2.85)	1.19 (0.66-2.27)	1.21 (0.75-2.06)	0.002

BMI, body mass index; CHD, coronary heart disease; DBP, diastolic blood pressure; HDL-C, high-density lipoprotein cholesterol; SD, standard deviation; SBP, systolic blood pressure

Table 2. Hazard ratios of respiratory diseases according to the frequency of sauna bathing

Frequency of sauna bathing (times/week)	Events/ Total	Model 1		Model 2		Model 3	
		HR (95% CI)	*P*-value	HR (95% CI)	*P*-value	HR (95% CI)	*P*-value
≤ 1	119 / 501	ref		ref		ref	
2-3	238 / 1,262	0.66 (0.53 to 0.82)	< 0.001	0.68 (0.55 to 0.86)	0.001	0.73 (0.58 to 0.92)	0.007
≥ 4	22 / 172	0.49 (0.31 to 0.77)	0.002	0.53 (0.34 to 0.84)	0.007	0.59 (0.37 to 0.94)	0.026

CI, confidence interval; HR, hazard ratio; ref, reference

Model 1: Adjusted for age

Model 2: Model 1 plus body mass index, smoking status, history of diabetes, prevalent coronary heart disease, years of education, and alcohol consumption

Model 3: Model 2 plus total energy intake, socioeconomic status, physical activity, and C-reactive protein