Frequent sauna bathing offsets the increased risk of death due to low socioeconomic status: A prospective cohort study of middle-aged and older men

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ABSTRACT

Background and aim: Low socioeconomic status (SES) and frequent sauna bathing are associated with increased and decreased risk of all-cause mortality, respectively. Whether there is an interplay among SES, sauna bathing and all-cause mortality risk is not known. We aimed to evaluate the separate and joint associations of SES and frequency of sauna bathing (FSB) with all-cause mortality risk in a prospective cohort study.

Methods: We employed the Kuopio Ischaemic Heart Disease Study cohort comprising of 2575 men aged 42–61 years at study entry. Self-reported SES and sauna bathing habits were assessed at baseline. Socioeconomic status was categorized as low and high (median cutoff) and FSB as low and high (defined as \( \leq 2 \) and \( 3–7 \) sessions/week, respectively).

Results: During a median follow-up of 27.8 years, 1618 deaths occurred. Comparing low vs high SES, the multivariable-adjusted HR (95% CI) for all-cause mortality was 1.31 (1.18–1.45). Comparing high vs low FSB, the multivariable-adjusted HR (95% CI) for all-cause mortality was 0.86 (0.76–0.97). Compared with high SES-low FSB, low SES-low FSB was associated with an increased risk of all-cause mortality 1.35 (1.20–1.51), without significant evidence of an association for low SES-high FSB and all-cause mortality risk 1.07 (0.89–1.29). Positive additive and multiplicative interactions were found between SES and FSB.

Conclusions: There exists an interplay among SES, sauna bathing and all-cause mortality risk in a general Finnish male population. Frequent sauna baths may offset the increased overall mortality risk due to low SES.

1. Introduction

In 2019, non-communicable diseases accounted for 74% of deaths globally, with ischemic heart disease and stroke being the leading causes (WHO, 2020). A large proportion of global cause-specific and all-cause deaths has been attributed to modifiable risk factors including smoking, unhealthy diets, heavy alcohol intake, physical inactivity, and air pollution (Collaborators, 2020). Though several epidemiological investigations including the Global Burden of Disease Study and Prospective Urban Rural Epidemiology Study, have reported on the relationships between various individual risk factors and mortality and provided global estimates of the effect of multiple modifiable risk factors on mortality (Collaborators, 2020; Stringhini et al., 2017; Yusuf et al., 2020), data on the joint contributions of these risk factors to mortality risk is limited.

Socioeconomic status (SES) is a risk factor which is known to have a
measurable and significant effect on cardiovascular health (Stringhini et al., 2017). Low SES has been shown to be strongly linked with the development of cardiovascular disease (CVD) (Sundquist et al., 2004), the leading cause of death globally (WHO, 2020). Several epidemiological investigations have also demonstrated robust associations between low SES and elevated mortality risk (Stringhini et al., 2017).

Sauna bathing, a form of passive heat therapy, is an activity that has mainly been used for the purposes of pleasure, relaxation and wellness (J.A. Laukkanen et al., 2018b). Frequent sauna bathing has plentiful health benefits (Patrick and Johnson, 2021); these include improvement in pain and symptoms associated with musculoskeletal diseases (Nurmikko and Hietarajju, 1992); treatment of chronic headache (Kanji et al., 2015); improvement in cardiovascular function (T. Laukkanen et al., 2018; Lee et al., 2018); and reduced risk of respiratory diseases (Kunutsor et al., 2017a; Kunutsor et al., 2017b), hypertension (Zaccardelli et al., 2017), and neurocognitive disease (Kunutsor et al., 2017a). Frequent sauna baths have also been shown to be strongly associated with reduced risk of fatal cardiovascular as well as all-cause mortality events (Kunutsor et al., 2018b; J.A. Laukkanen et al., 2018a; Laukkanen and Kunutsor, 2019; J.A. Laukkanen et al., 2018b; Laukkanen et al. 2015). Regular sauna bathing may potentiate the beneficial effects of lifestyle factors such as exercise and physical fitness (Kunutsor et al., 2018a; J.A. Laukkanen et al., 2018a) in addition to offsetting the adverse effects of other risk factors such as inflammation (as measured by C-reactive protein, CRP) and low SES (Kunutsor et al., 2021a; Kunutsor et al., 2022). Given the overall evidence, we hypothesize that there might exist an interplay among SES, sauna bathing, and mortality risk. Whether frequent sauna baths could attenuate or offset the increased risk of mortality due to low SES has not been previously explored. Using a population-based prospective cohort of 2575 middle-aged to older Finnish men, we sought to (i) evaluate the joint effects of SES and frequency of sauna bathing (FSB) on the risk of all-cause mortality and (ii) replicate the separate and independent associations of SES and FSB with the risk of all-cause mortality.

2. Materials and methods

Reporting of the study conforms to broad EQUATOR guidelines (Simera et al., 2010) and was conducted according to STROBE (STrengthening the Reporting of OBservational studies in Epidemiology) guidelines for reporting observational studies in epidemiology (Supplementary material 1). The study population for this analysis included participants in the Kuopio Ischemic Heart Disease (KIHD) risk factor study, a prospective population-based cohort study designed to investigate risk factors for vascular disease and other chronic outcomes. The study design and recruited methods have been described in previous reports (Kunutsor et al., 2018a; Kunutsor et al., 2018b). Briefly, participants recruited comprised a representative sample of men aged 42–61 years living in the city of Kuopio and its surrounding rural communities in eastern Finland at the time of baseline examinations conducted between March 1984 and December 1989. The study was approved by the Research Ethics Committee of the University of Eastern Finland and each participant provided written informed consent. Socioeconomic status, which was assessed using self-reported questionnaires, involved a summary index that combined measures of income, education, occupational prestige, material standard of living and housing conditions (Jae et al., 2021). The items for each indicator were scored and summed. For material standard of living, a material possession index was based on self-reports of ownership of 12 items (color TV, video tape recorder, freezer, dish washer, car, motorcycle, telephone, summer cottage, house trailer, motorboat, sailing boat, and ski mobile). An individual score was derived from the ownership of the 12 items and divided by the total number of item responses. The composite SES index ranged from 0 to 25, with higher values indicating lower SES. Sauna bathing habits (weekly frequency and duration of sauna sessions) were assessed using a standardised self-administered questionnaire (Kunutsor et al., 2018a; Kunutsor et al., 2018b; J.A. Laukkanen et al., 2018a). Physical activity (PA) was assessed from a 12-month leisure-time physical activity (LTPA) questionnaire (Kunutsor et al., 2020) modified from the Minnesota LTPA Questionnaire (Taylor et al., 1978). The KIHD LTPA Questionnaire showed high reproductibility and provides a useful measure of average weekly leisure-time activity over a 1-year period (Lakka and Salonen, 1992).

We included all deaths that occurred from study entry through to 2018. Information on mortality outcomes was ascertained by computerized data linkage to the Finnish national hospital discharge registry and death certificate registers.

Multivariable-adjusted hazard ratios (HRs) with 95% confidence intervals (CIs) for all-cause mortality were calculated using Cox proportional hazard models. To maintain consistency with previous reports (Kunutsor et al., 2021a; Kunutsor et al., 2021b; Kunutsor et al., 2018a; J.A. Laukkanen et al., 2018a), SES was categorized as low and high (based on the median cutoff) and FSB as low and high (defined as ≤2 and 3–7 sauna sessions per week respectively). The joint association of SES and FSB with all-cause mortality risk was based on the following four possible groups: high SES-low FSB; high SES-high FSB; low SES-low FSB; and low SES-high FSB. Interactions between SES and FSB were evaluated on both the additive and multiplicative scales in relation to all-cause mortality risk. Additive interactions were assessed using the “relative excess risk due to interaction” (RERI), computed for binary variables as RERI(R) (two-way interaction) = HR1,1 – HR1,0 – HR0,1 + 1 (Li and Chambers, 2007). Multiplicative interactions were assessed using the ratio of HRs (two-way interaction) = HR1,1 / (HR0,0 × HR1,0) (Li and Chambers, 2007). A positive additive interaction is indicated if RERI > 0 and a positive multiplicative interaction is indicated if the ratio of HRs > 1. All statistical analyses were conducted using Stata version MP 17 (Stata Corp, College Station, Texas).

3. Results

The overall mean (standard deviation, SD) age of men at baseline was 52 (5) years. The mean (SD) and median (interquartile range, IQR) values for SES and FSB were 8.49 (4.23) and 2 (1–2) sessions/week, respectively (Table 1). Men with low SES-high FSB consumed less alcohol and had higher levels of body mass index (BMI); whereas those with low SES-low FSB smoked more, were more likely to have comorbidities such as type 2 diabetes (T2D) and coronary heart disease (CHD) and had higher levels of total cholesterol and high-sensitivity CRP (Table 1).

During a median (IQR) follow-up of 27.8 (18.4–31.1) years, 1618 deaths (annual rate 26.04/1000 person-years at risk, 95% CI: 24.04 to 27.34) occurred. Of the total deaths, 744 (46.0%) were due to cardiovascular causes. The most common primary cause for cardiovascular deaths was CHD (n = 496). Men with low SES-low FSB were more likely to die overall or from cardiovascular causes (Table 1).

Compared with men with high SES, low SES was associated with an increased risk of all-cause mortality in age-adjusted analysis (Model 1) 1.53 (95% CI: 1.38–1.69) (Fig. 1), which was minimally attenuated following further adjustment for BMI, systolic blood pressure, total cholesterol, high-density lipoprotein cholesterol, smoking status, history of T2D or CHD, alcohol consumption, PA, and high-sensitivity CRP (Model 2) 1.51 (95% CI: 1.18–1.45) (Fig. 1). The association remained unchanged after further adjustment for FSB 1.31 (95% CI: 1.18–1.45). On adjustment for the covariates in Model 2 above, high FSB was associated with a decreased risk of all-cause mortality compared with low FSB 0.85 (95% CI: 0.75–0.97) (Fig. 1), which remained persistent on additional adjustment for SES 0.86 (95% CI: 0.76–0.97).

In joint association analysis, compared with men with high SES-low FSB, multivariable-adjusted analysis (Model 2) showed that low SES-low FSB was associated with an increased risk of all-cause mortality 1.35 (95% CI: 1.20–1.51), with no significant evidence of an association for low SES-high FSB and all-cause mortality risk 1.07 (95% CI: 0.89–1.29).
Baseline characteristics of study participants.

| Characteristics | Overall (N = 2575) | High SES-low FSB (N = 1092) | High SES-high FSB (N = 347) | Low SES-low FSB (N = 923) | Low SES-high FSB (N = 1313) |
|-----------------|--------------------|------------------------------|----------------------------|--------------------------|-----------------------------|
| **SES**         |                    |                              |                            |                          |                             |
| Low SES         | 8.49 (4.23)        | 5.50 (2.65)                  | 5.03 (2.59)                | 12.46 (2.01)             | 12.30 (1.79)                |
| FSB (sessions/week) | 2 (1-2)          | 2 (1-2)                      | 3 (3-4)                    | 2 (1-2)                  | 3 (3-4)                     |
| **Questionnaire/prevalent conditions** |                    |                              |                            |                          |                             |
| Age, years      | 53 (5)             | 52 (5)                       | 51 (6)                     | 54 (4)                   | 54 (5)                      |
| Alcohol consumption, g/week | 31.8 (6.3-91.5)   | 32.9 (7.6-88.2)              | 43.5 (10.6-104.3)          | 25.2 (3.3-95.8)          | 22.0 (3.2-83.0)             |
| Current smoking, % | 814 (31.6)       | 313 (28.7)                   | 75 (21.6)                  | 363 (39.3)               | 63 (29.6)                   |
| History of T2D, % | 104 (4.0)        | 41 (3.8)                     | 7 (2.0)                    | 51 (5.5)                 | 5 (2.4)                     |
| History of CHD, % | 649 (25.2)       | 206 (18.9)                   | 61 (17.6)                  | 322 (34.9)               | 60 (28.2)                   |
| **Physical measurements** |                    |                              |                            |                          |                             |
| BMI, kg/m^2     | 26.9 (3.6)         | 26.8 (3.5)                   | 26.9 (3.4)                 | 26.9 (3.7)               | 27.2 (3.8)                  |
| SBP, mm Hg      | 134 (17)           | 134 (17)                     | 132 (15)                   | 135 (15)                 | 135 (15)                    |
| DBP, mm Hg      | 89 (11)            | 89 (11)                      | 88 (9)                     | 89 (11)                  | 88 (11)                     |
| Physical activity (kI/day) | 1204 (628-2000) | 1220 (658-2002)              | 1397 (786-2172)            | 1089 (571-1892)          | 1098 (512-2016)             |
| **Blood biomarkers** |                 |                              |                            |                          |                             |
| Total cholesterol, mmol/l | 5.91 (1.08)     | 5.80 (1.03)                  | 5.82 (1.06)                | 6.05 (1.10)              | 6.00 (1.19)                 |
| HDL-C, mmol/l   | 1.29 (0.30)        | 1.27 (0.29)                  | 1.33 (0.31)                | 1.31 (0.31)              | 1.32 (0.30)                 |
| High sensitivity CRP, mg/l | 1.29 (0.71-2.48) | 1.22 (0.66-2.34)             | 1.05 (0.64-2.08)           | 1.51 (0.77-2.84)         | 1.41 (0.83-2.40)            |
| Mortality events | 1618 (62.8)       | 603 (55.2)                   | 166 (47.8)                 | 704 (76.3)               | 145 (68.1)                  |
| All-cause mortality, % | 744 (28.9)      | 287 (26.3)                   | 75 (21.6)                  | 326 (35.3)               | 56 (26.3)                   |
| CHD mortality, % | 496 (19.3)        | 184 (16.9)                   | 51 (14.7)                  | 220 (23.8)               | 41 (19.3)                   |

BMI, body mass index; CHD, coronary heart disease; CRP, C-reactive protein; CVD, cardiovascular disease; DBP, diastolic blood pressure; FSB, frequency of sauna bathing; HDL-C, high-density lipoprotein cholesterol; IQR, interquartile range; SBP, systolic blood pressure; SD, standard deviation; SES, socioeconomic status; T2D, type 2 diabetes.

Model 1: Adjusted for age.

Model 2: Model 1 plus body mass index, systolic blood pressure, total cholesterol, high-density lipoprotein cholesterol, smoking status, history of type 2 diabetes, history of coronary heart disease, alcohol consumption, physical activity, high sensitivity C-reactive protein.

Model 3: Model 2 plus FSB for SES or SES for FSB.

(Fig. 1) In interaction analysis, the RERI was 0.21 and the ratio of HRs was 1.15, denoting the presence of additive and multiplicative interactions.

Given that the categorization of SES into two groups might not truly reflect low and high SES, we conducted a subsidiary analysis in which SES was categorized as low, moderate and high (based on tertiles cutoff) and we re-evaluated the joint associations of SES and FSB with all-cause mortality risk based on the following six possible groups: high SES-low FSB; high SES-high FSB; moderate SES-low FSB; moderate SES-high FSB; low SES-low FSB; and low SES-high FSB. Our results were consistent with the main findings: low SES-low FSB was associated with an increased risk of all-cause mortality 1.45 (95 % CI: 1.26–1.68), with no significant evidence of an association for low SES-high FSB and all-cause mortality risk 1.09 (95 % CI: 0.87–1.38) (Supplementary material 2).

4. Discussion

Consistent with previous reports (Kunutsor et al., 2018a; Stringhini et al., 2018).

Fig. 1. Separate and joint associations of socioeconomic status and frequency of sauna bathing with risk of all-cause mortality. CI, confidence interval; FSB, frequency of sauna bathing; HR, hazard ratio; ref., reference; SES, socioeconomic status.
et al., 2017; Zhang et al., 2021), lower SES was associated with an increased risk of all-cause mortality, whereas higher FSB was associated with a decreased risk of all-cause mortality. The associations were independent of several established risk factors as well as mutual adjustment for each exposure. New findings in our Finnish population, based on the joint associations of SES and FSB with all-cause mortality risk showed that mortality was increased in men with both low SES and low FSB, but the risk was attenuated to null for the combination of low SES and high FSB. The results persisted when SES was categorized into three groups (low, medium and high), further confirming that frequent sauna bathing may offset the increased risk of mortality in individuals with very low SES. Formal interactions analysis demonstrated positive and multiplicative interactions between SES and FSB in relation to mortality risk.

There are robust associations between SES and adverse health outcomes including CVD and mortality (Stringhini et al., 2017; Sundquist et al., 2004). Biological, behavioral, and psychosocial risk factors prevalent in socioeconomically deprived individuals may accentuate the relationship between low SES and these adverse health outcomes (Schultz et al., 2018). These include lower levels of education; poor dietary habits; unhealthy lifestyles such as smoking, physical inactivity and excessive alcohol consumption; limited access to health care; higher prevalence of comorbid conditions; and general poor health status (Hujova and Rostakova, 2013; Subramanian et al., 2013). Indeed, our cross-sectional analysis showed that study participants in the low SES-low FSB group were more likely to smoke, have pre-existing conditions such as T2D and CHD, and have higher circulating levels of risk factors such as total cholesterol and high-sensitivity CRP. There is mounting evidence on comparable physiological changes between sauna bathing and aerobic exercise (Thomas, 2017); there appear to be similarities in health benefits between both activities. The mechanistic pathways by which frequent sauna baths (passive heat therapy) could decrease the risk of adverse health conditions and subsequently death include (i) improvement in vascular endothelial and cardiac function (Kihara et al., 2002), (ii) positive alterations in arterial stiffness and haemodynamics (Lee et al., 2018), (iii) reduction in oxidative stress (Masuda et al., 2004), inflammation, and blood pressure levels (Zaccardi et al., 2017), (iv) beneficial modulation of the autonomic nervous system (Laukkanen et al., 2019), (v) decrease in levels of risk factors such as natriuretic peptides (J.A. Laukkanen et al., 2018b; Miyata et al., 2008), and (vi) boosting of the immune system (Kunutsor et al., 2021c). Like PA, frequent sauna baths have been shown to exhibit synergistic effects when combined with other protective lifestyle interventions (Kunutsor et al., 2018a; Kunutsor and Laukkanen, 2021; J.A. Laukkanen et al., 2018a), and also neutralize the adverse effects of other risk factors (Kunutsor et al., 2021a; Kunutsor et al., 2022). Taking the whole evidence together, it appears that the protective effects exerted by frequent sauna baths are large enough to offset the adverse effects of low SES. However, mechanistic and definitive studies are needed to prove this.

There is an increasing wealth of evidence on the potential health benefits of passive heat therapies such as repeated hot water immersion, infrared-ray sauna, Waon therapy, Turkish bath and Finnish saunas (J.A. Laukkanen et al., 2018b). However, the Finnish sauna is the most widely studied form of heat therapy to date, with consistent evidence on its benefits (J.A. Laukkanen et al., 2018b). Further studies are needed to delineate and confirm the potential pathways underlying the survival benefits of sauna use and how these findings could be translated and integrated into clinical practice. It could be argued that sauna bathing is only commonly used in Finland and other Nordic countries and also widely accessible to most people including those with low SES, hence, its potential clinical applications cannot be translated to other populations with low SES who do not have access to saunas. Nevertheless, over the last decade, there has been a steep increase in research outputs on the potential health benefits of sauna (Patrick and Johnson, 2021), and its use as a pastime and/or for the treatment of various conditions has increased globally. Just like PA, maybe it is time to start promoting sauna use via clinical practice and population-wide approaches. Implementing policies such as provision of affordable sauna infrastructure, making it accessible for all population groups, and encouraging their use, might increase population levels of sauna use and subsequently reduce disease risk.

We have conducted the first evaluation of the interplay among SES, sauna bathing and all-cause mortality risk. Other strengths that deserve consideration include the population-based prospective cohort design, the relatively large sample size and high event rate, long-term follow-up which was sufficient for events to occur, and comprehensive analysis including adjustment for several potential confounders and formal interaction analysis (two-way additive and multiplicative interactions, RERI and ratio of HRs). The limitations are mostly inherent to the study design and include (i) the chance of type 1 error due to multiplicity (Patel and Ioannidis, 2014), given the use of the KIHDS study to test multiple variables for associations with other exposures and mortality outcomes; (ii) the possibility of regression dilution bias given the use of single baseline measurements of SES and FSB; (iii) the current material possession index may be a less sensitive indicator of SES, but this was not used in isolation, but in combination with other key measures such as income, education, and occupation; and (iv) the inability to generalise the findings to women, other age groups and especially other populations that do not have access to saunas.

In conclusion, low SES and frequent sauna baths are associated with increased and decreased risk of mortality, respectively, in a general Finnish male population. There exists a significant interplay among SES, sauna bathing, and the risk of death. Socioeconomic status interacts with sauna bathing on the risk of death; the increased mortality related to low SES is offset by frequent sauna baths.

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CRediT authorship contribution statement

Setor K. Kunutsor: Conceptualization; Methodology; Data curation; Formal analysis; Investigation; Writing - Original draft preparation. Sae Young Jae: Conceptualization; Resources; Data curation; Writing - Reviewing and editing. Jari A. Laukkanen: Conceptualization; Data curation; Writing - Reviewing and editing.

Declaration of competing interest

The authors have no conflicts of interest to disclose.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.exger.2022.111906.

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