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# **Cardiovascular and Other Health Benefits of Sauna Bathing: A Review of the Evidence**

Running head: Sauna and Health Benefits

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## **Abstract**

Sauna bathing, an activity that has been a tradition in Finland for thousands of years and mainly used for the purposes of pleasure and relaxation, is becoming increasingly popular in many other populations. Emerging evidence suggests that beyond its use for pleasure, sauna bathing may be linked with several health benefits, which include reduction in the risk of vascular diseases such as high blood pressure, cardiovascular disease, neurocognitive diseases; non-vascular conditions such as pulmonary diseases; and mortality, as well as the amelioration of conditions such as arthritis, headache and flu. The beneficial effects of sauna bathing on these outcomes have been linked to its impact on circulatory, cardiovascular and immune function. It has been postulated that regular sauna bathing may improve cardiovascular function via improved endothelium-dependent dilatation, reduced arterial stiffness, modulation of the autonomic nervous system, beneficial changes of circulating lipid profiles, and lowering of systemic blood pressure. This review summarizes the available epidemiological, experimental and interventional evidence linking Finnish sauna bathing and its effects on cardiovascular outcomes and other disease conditions on the basis of a comprehensive search for observational studies, randomized controlled trials (RCTs), and non-RCTs from MEDLINE and EMBASE since their inception till February 2018. An overview of the postulated biologic mechanisms underlying the associations between sauna bathing and its health benefits, areas of outstanding uncertainty, and the implications for clinical practice are also discussed.

**Keywords** Finnish sauna bathing; vascular disease; blood pressure; dementia; Alzheimer's disease; pulmonary disease; mortality

## **Abbreviations**

BP=blood pressure; CHD=coronary heart disease; CRF = cardiorespiratory fitness; CRP = C-reactive protein; CVD=cardiovascular disease; RCT= randomized controlled trial; SCD = sudden cardiac death

## **Introduction**

Finnish sauna bathing has been used for the purposes of pleasure, wellness and relaxation. It is a tradition embedded in the culture in Finland, and it is accessible basically to everyone.<sup>1,2</sup> Beyond its use for pleasure, emerging evidence suggests that sauna bathing might offer a multitude of health benefits.

Accumulating evidence suggests that regular sauna bathing may alleviate and prevent the risk of both acute and chronic disease conditions. During the past decade, a considerable amount of research data from various countries on the potential health benefits of sauna bathing as well as the putative biological pathways underlying these effects have been reported. Given the mixed evidence from the literature, there is a need to aggregate the data to enable appropriate interpretation. This review summarizes the available epidemiological, experimental, and interventional evidence linking sauna bathing, cardiovascular outcomes and other health benefits; the postulated biologic mechanisms underlying these associations; outlines areas of outstanding uncertainty; and the implications for clinical practice. Given that there are different forms of passive heat therapy (eg. repeated hot water immersion, infrared-ray sauna, Waon therapy, Turkish bath, etc), this review will only focus on evidence from the traditional Finnish saunas since they are the most widely studied to date.

We sought observational (prospective cohort, nested case-control, or case-control, retrospective cohort) studies, randomized controlled trials (RCTs), and non-RCTs from MEDLINE and EMBASE from their inception till February 2018; with particular emphasis on Finnish sauna baths. Search terms included “sauna bath”, “Finnish”, “cardiovascular disease”, “coronary heart disease”, “sudden cardiac death”, “heart failure”, “hypertension”, “blood pressure”, “dementia”, “depression”, “pulmonary disease”, “mortality”, “lipids”, “natriuretic peptides”, “hormones”, “endothelial function”, “inflammation”, “oxidative stress”, “arterial stiffness”, “arterial compliance”, and “intima media thickness”. Studies were limited to those in conducted in humans, adults and written in English.

## **ARTICLE HIGHLIGHTS**

- Finnish sauna bathing, which is characterized by exposure to a high environmental temperature (80 - 100 °C) for a brief period, has traditionally been used for the purposes of pleasure and relaxation.
- Beyond pleasure and relaxation, emerging evidence suggests that sauna bathing has several health benefits, which include reduction in the risk of vascular outcomes such as high blood pressure, cardiovascular disease (CVD), stroke, neurocognitive diseases; non-vascular conditions such as pulmonary diseases including common flu; mortality; treatment of specific skin conditions; as well as for the relief of pain in conditions such as rheumatic diseases and headache.
- The physiologic responses produced by an ordinary sauna bath corresponds to that produced by moderate or high intensity physical activity such as walking.
- The beneficial effects of sauna baths on CVD and mortality may be mediated via reduction in blood pressure; improvement in endothelial function; reduction in oxidative stress and inflammation; beneficial modulation of the autonomic nervous system; improved lipid profile and arterial compliance; and improvement in the cardiorespiratory system.
- Sauna bathing is a safe activity and can even be used in patients with stable CVD, provided it is used sensibly for an appropriate period of time.

## **Sauna bathing**

Sauna bathing is a form of passive heat therapy which is characterized by exposure to a high environmental temperature for a brief period. The typical Finnish sauna is characterized by dry air and relatively high temperature. Temperature and humidity can be temporarily increased by throwing water on the hot rocks of sauna heater, which is the heating source of the 80 - 100 °C temperature in sauna. The sauna is usually made up of log or wood with wooden benches well above the floor for bathers to sit on. The recommended temperature for a sauna bath is from 80°C to 100°C at the level of the bather's head, but it is lower at the floor-level which ensures efficient ventilation and makes sure the conditions are comfortable for sauna bathers.<sup>3</sup> The relative humidity of sauna usually varies from 10 to 20%. Typical sauna sessions consist of short stays in the sauna room which is interspersed with cooling-off periods (swim, shower, or a period at room temperature). The duration of stay in the sauna room depends on the comfort and temperature of the sauna bather, but it usually ranges from 5-20 minutes, although longer sauna bathing sessions may be used depending on the individual.<sup>4</sup> Sauna bathing habits may have changed over time, but still a typical Finnish person has a sauna bath at least once per week, with the average habitual frequency being 2-3 times per week.<sup>5-7</sup>

During a sauna session, heart rate may increase from baseline up to 120-150 beats per minute. There is no active function of skeletal muscles during the sauna bathing, which is in contrast to the training response experienced during physical exercise. A part of blood volume is diverted from the internal organs to body peripheral parts with decreasing venous return which is not facilitated by active skeletal muscle work.<sup>8</sup> However, it has been proposed that muscle blood flow may increase to at least some extent in response to heat stress.<sup>9</sup>

## **Sauna Bathing and Vascular Outcomes**

### ***Blood pressure or Hypertension***

Evidence from a number of experimental and epidemiological studies implicates sauna bathing to have a positive effect on blood pressure (BP) modulation. However, it appears majority of these reports were conducted in patients with pre-existing vascular disease and/or only evaluated the short-term effects of sauna exposure on BP.<sup>10, 11</sup> Two recent experimental studies by Laukkanen et al and

Lee et al among 100 men and women (56% male, age 32-75 years) with at least one cardiovascular risk factor, showed reductions in both systolic and diastolic BP 30 minutes sauna bathing sessions<sup>7, 12</sup> In addition to the decreases in BP, sauna bathing led to positive alterations in measures of arterial stiffness such as pulse wave velocity.<sup>12</sup> Mean carotid–femoral pulse wave velocity was 9.8 (2.4) m/s before sauna and decreased to 8.6 (1.6) m/s immediately after sauna ( $p < 0.0001$ ). Mean systolic BP decreased after sauna exposure from 137 (16) to 130 (14) mmHg ( $p < 0.0001$ ) and diastolic BP from 82 (10) to 75 (9) mmHg ( $p < 0.0001$ ). Systolic BP after 30min recovery remained lower compared to pre-sauna levels. Gayda et al studied the effects of sauna alone as an intervention versus the combination of exercise and sauna on ambulatory BP monitoring and central hemodynamic variables in 16 patients with slightly elevated BP. There were 8 prehypertensive patients (systolic BP 120 mm Hg to 139 mm Hg) and 8 stage I hypertensive patients (systolic BP 140 mm Hg to 159 mm Hg).<sup>13</sup> A single sauna session produced positive effects on systemic BP assessed by 24-hour BP recordings. On the basis of this relatively small sauna-intervention study, the authors proposed that both exercise and sauna were important non-pharmacological strategies to reduce systolic and mean BP in patients with untreated hypertension.<sup>13</sup>

There is limited evidence on the long-term effects of habitual sauna bathing on BP or the risk of hypertension, especially in general population settings. In the only long-term prospective cohort study by Zaccardi et al. conducted to date among 1,621 men (42-60 years) recruited from the general population, it was shown that Caucasian men who took frequent sauna baths (4-7 sessions per week) had about a 47% reduced risk of developing future hypertension when followed-up for over a period of 24.7 years.<sup>14</sup> In this study, participants had resting blood pressure ranging within normal limits and were not using antihypertensive medication at the baseline examination.<sup>14</sup> These results were adjusted for established risk factors and several other potential confounders that could have influenced the risk of hypertension such as alcohol consumption, socioeconomic background and the level of cardiorespiratory fitness (CRF). Regular sauna bathing habits may be beneficial in the reduction of high systemic BP; however, to confirm if there is a protective effect of long-term sauna bathing on the risk of hypertension will need robust evidence from a well-designed RCT. The **Table** summarizes

relevant characteristics and results of key studies that have reported on the associations of sauna bathing with vascular and non-vascular outcomes.

### *Cardiovascular Disease*

The protective effects of Finnish sauna may also reflect life-long habits, which may be at least partly comparable with the health effects of long-term physical activity. Though several studies have suggested a beneficial effect of sauna bathing on indices of cardiovascular function;<sup>11, 13</sup> to our knowledge, only two reports have investigated the effects of regular sauna bathing on the long-term risk of cardiovascular disease (CVD). In a prospective cohort study of 2315 Finnish men by Laukkanen et al. followed over a period of 20.7 years, increased frequency and duration of sauna bathing was shown to be inversely and independently associated with the risk of sudden cardiac death (SCD), fatal coronary heart disease (CHD) and CVD, and all-cause mortality.<sup>6</sup> In this study,<sup>6</sup> the analyses took into account a comprehensive panel of confounders that could have influenced the risk of outcomes and these included age, body mass index, systolic blood pressure, serum low-density lipoprotein, cholesterol level, smoking, alcohol consumption, previous myocardial infarction, type 2 diabetes mellitus, CRF, resting heart rate, physical activity, and socioeconomic status. Contrary to limited evidence linking sauna baths to an increased risk of SCDs,<sup>3</sup> this long-term study conducted among Finnish men demonstrated increase in sauna bathing habits (frequency and duration) to be each associated with a reduced risk of SCD (**Table** and **Figure 1**). Kunutsor et al. showed in another prospective cohort study of 1628 men and women followed up for over 15 years, that having regular sauna baths (4-7 sessions per week) compared with one sauna session per week, was associated with about a 62% reduced risk of incident stroke.<sup>15</sup> The association was similar for stroke subtypes (ischemic and hemorrhagic stroke). There have been suggestions that a combination of regular physical activity and sauna baths may confer more protection on cardiovascular outcomes. In two recent studies based on a general male Finnish population, the combined effect of high CRF level and frequent sauna baths was demonstrated to be associated with a substantially lowered risk of future cardiovascular deaths, SCD, and all-cause mortality outcomes compared with high CRF or frequent sauna bathing alone.<sup>5, 16</sup> These recent findings have practical implications; which indicate that good

CRF levels which can usually be improved by regular physical exercise, when combined with frequent sauna bathing sessions can substantially reduce the risk of these adverse cardiovascular outcomes. Evidence from well-designed intervention studies are needed to confirm if the associations between good CRF, sauna bathing and CVD outcomes are causal.

### ***Neurocognitive Disease***

The etiology of neurocognitive disease is a multifactorial, with impaired cardiovascular function, inflammation and oxidative stress postulated as being major contributors in its pathogenesis; in addition to high systemic BP with elevated levels of common cardiovascular risk factors.<sup>17, 18</sup>

Emerging recent evidence suggests that sauna exposure may have protective effects on neurocognitive disease. In a population-based prospective cohort study by Laukkanen et al. conducted in 2315 apparently healthy Finnish men aged 42-60 years at baseline; compared to men who had one sauna session per week, men who had 4-7 sauna sessions per week had a 66% and 65% reduced risk of future dementia and Alzheimer's disease respectively.<sup>19</sup> Whether sauna exposure exerts its neurocognitive protective effects via mediation in the pathways contributing to these diseases or it's just an enjoyable activity which prevents or delays the development of these memory diseases is not clearly understood.

### **Sauna Bathing and Non-Vascular Diseases**

#### ***Pulmonary Disease***

In addition to the potential beneficial effects of sauna bathing on several vascular outcomes, sauna bathing has also been suggested to have beneficial effects on some non-vascular conditions. Evidence suggests that sauna bathing improves lung function by improving vital capacity and volume, ventilation, and forced expiratory volume.<sup>20, 21</sup> Cox et al. studied the influence of sauna on pulmonary functioning in 12 male participants with obstructive pulmonary disease and concluded that sauna caused transient improvement of lung function in these patients,<sup>21</sup> whereas Laitinen et. al in a review evaluated previous research on the topic showing sauna exposure to improve breathing in patients with asthma or chronic bronchitis.<sup>20</sup> Ernst et al. in a trial of 25 volunteers who were exposed

to sauna and 25 controls, sauna bathing was observed to half the incidence of common colds in the sauna group during the last three months of the study period.<sup>22</sup> In the first prospective evaluation of the long-term effect of sauna bathing on the risk of pulmonary disease, Kunutsor et al. found that moderate (2-3 sessions per week) to high frequency (4-7 sessions per week) sauna bathing is associated with a reduced risk of respiratory diseases (defined as chronic obstructive pulmonary disease, asthma, or pneumonia).<sup>23</sup> In a separate analysis limited to pneumonia cases, having regular sauna baths, was also associated with a reduced risk of future pneumonia.<sup>24</sup>

### **Sauna Bathing and Other Health Benefits**

Sauna bathing has been linked with an improvement in the pain and symptoms associated with musculoskeletal disorders such as osteoarthritis, rheumatoid arthritis, and fibromyalgia.<sup>25, 26</sup> Having sauna baths also improve headache disorders. In a RCT by Kanji et al., 37 people with chronic tension-type headache were randomized to regular sauna bathing or advice and education for a period of 8 weeks and sauna therapy was demonstrated to substantially and significantly improve headache intensity.<sup>27</sup> Though there is some evidence from a Japanese study that thermal therapy improved the symptoms of patients with mild depression;<sup>28</sup> to our knowledge, no study has as yet reported the effects of Finnish sauna bathing on depression. However, we have recently shown that men who had 4-7 sauna sessions per week had a 78% reduced risk of developing psychosis in the future compared to men who only had one sauna session per week.<sup>29</sup> Though there is no robust evidence to suggest that sauna bathing can be used to treat or prevent skin disease; a study has suggested that sauna bathing may be of benefit to patients with psoriasis as it facilitates the removal of the hyperkeratotic scales.<sup>30</sup> Indeed, a previous study has suggested a protective effect of regular Finnish sauna on skin physiology as evidenced by stability of the epidermal barrier function, increase in hydration of the stratum corneum, and faster recovery of elevated water loss and skin pH.<sup>31</sup> Having regular sauna baths has also been reported to be associated with a better health-related quality of life. In a cross-sectional analysis of 524 octogenarians followed up in a longitudinal cohort study by Strandberg et al., physical function, vitality, social functioning, and general health were reported to be significantly better among those who were sauna users compared with non-users.<sup>32</sup>

## **Pathways Implicated on the Health Benefits of Sauna Bathing**

Traditionally, sauna baths have been used for the purposes of pleasure and relaxation, which evidently reduce the stresses of everyday life.. In addition, several mechanistic pathways have been proposed to underlie the effects of sauna bathing on vascular and non-vascular disease conditions. Evidence suggests that the responses produced by an ordinary sauna bath corresponds to that produced by moderate or high intensity physical activity such as walking.<sup>33</sup> Pathways implicated for the effect of sauna bathing on vascular disease and mortality risk include reduction in systemic BP;<sup>34</sup> improvement in endothelial function;<sup>35-37</sup> reduction in oxidative stress<sup>38, 39</sup> and inflammation;<sup>40, 41</sup> beneficial modulation of the autonomic nervous system;<sup>11</sup> positive alteration in levels of circulating vascular risk factors such as natriuretic peptides<sup>42</sup> and lipids;<sup>43, 44</sup> hormonal changes; improved arterial stiffness, arterial compliance, and intima media thickness;<sup>7, 38, 42, 45, 46</sup> and improvement in the cardiorespiratory system<sup>47</sup> as well as cardiovascular function<sup>3, 4, 48</sup> (**Figure 2**). Indeed, these pathways are involved in the pathophysiology of chronic disease outcomes such as type 2 diabetes and CVD, as well as mortality. Though the evidence on some of these pathways have been based on studies of other passive heat therapies such as Waon therapy, infra-red saunas, and hot water immersion, there is a biological plausibility that Finnish sauna baths may exhibit these similar effects. A typical hot and dry Finnish sauna increases body temperature which causes more efficient skin blood flow, leading to increased cardiac output; whereas blood flow to internal organs decrease.<sup>3, 4</sup> Increased sweating is accompanied by reduction in BP and a higher heart rate, while cardiac stroke volume is maintained.<sup>3, 33</sup> Sauna bathing stimulates hormonal changes which include increases in levels of plasma renin, cortisol, and growth hormone.<sup>49</sup> There is stimulation of the sympathetic nervous system due to the high temperature, which increases the production of norepinephrine.<sup>50, 51</sup> Levels of norepinephrine induced by sauna exposure have been reported to be similar to that induced by maximal physical activity.<sup>52</sup> Sauna therapy may also exert its effects via the changes in levels of blood-based cardiovascular biomarkers such as markers of glucose metabolism and insulin resistance, natriuretic peptides, cardiac troponin T, and inflammatory markers such as interleukins and C-reactive protein

(CRP), although data on this topic is still very limited and further studies are warranted to elucidate these potential mechanisms.

We have recently shown that regular Finnish sauna baths is associated with a decrease in circulating levels of inflammatory markers such as high sensitivity CRP, fibrinogen, and leucocyte counts at baseline and long-term follow-up.<sup>40, 41</sup> Whether sauna bathing has any effects on circulating interleukins is currently unknown. Finnish sauna baths have also been demonstrated to positively modulate circulating levels of lipids such as total cholesterol, low-density lipoprotein cholesterol, high-density lipoprotein cholesterol and triglycerides.<sup>43, 44</sup> There is also evidence that sauna exposure could boost the immune system,<sup>53</sup> which may partly explain why sauna baths reduce susceptibility to common colds and prevents infections in healthy subjects.<sup>22</sup> Furthermore, the effect of sauna bathing on vascular and non-vascular diseases may in part be mediated via reduced oxidative stress, as oxidative processes are well known to be involved in the etiology of several disease conditions. However, the evidence on the effect of Finnish sauna bathing on oxidative stress has been mostly conflicting. While evidence has shown that a single sauna bath is able to reduce oxidative stress,<sup>38</sup> another study reports that sauna exposure might increase oxidative stress.<sup>54</sup> In addition to other potential pathways that might be involved, the effect of sauna on psychotic symptoms might be via an ability to promote mental health and well-being. The beneficial effect of sauna bathing on pulmonary conditions might be due to its direct effects on the airways and lung tissue, which include improvement in ventilation and lung function and reduction in pulmonary congestion.<sup>20</sup> The pain relieving pathways of sauna exposure on musculoskeletal conditions may be mediated via the sensory nerve endings in the skin.<sup>4</sup> It has been reported that the heat stress interspersed with intense cooling-off periods promotes the analgesic effects, as reflected by the increased circulating levels of beta-endorphins.<sup>55</sup> The feelings of relaxation and well-being associated with sauna sessions might be linked to the increased production of circulating levels of hormones such as endorphins.<sup>56</sup> Given the established role of physical activity in protecting against vascular and non-vascular disease as well as mortality and the emerging role of similar effects by sauna baths, the combination of both activities might have added health benefits. Indeed, we have recently shown that a combination of good fitness

levels produced by aerobic exercise and frequent sauna bathing confer more protection on the risk of cardiovascular and all-cause mortality.<sup>5, 16</sup> Further evidence is needed to demonstrate the mechanistic pathways linking sauna bath and its effect on non-fatal and fatal or intermediate cardiovascular outcomes as well as other health conditions with sub-clinical outcomes such as arterial wall changes, especially in general populations.

### **Adverse Effects of Sauna Bathing**

Sauna bathing is a pleasurable recreational activity, has a good safety profile, and most people in generally good health can tolerate a typical hot and dry Finnish sauna.<sup>3, 57</sup> There was previous anecdotal evidence that people with cardiovascular conditions are discouraged from having sauna baths because the hot and humid environment imposes a burden on the cardiovascular system.<sup>4, 58</sup> However, the overall findings from studies do suggest that sauna bathing is safe among patients with stable CVD, such as those who have recovered from myocardial infarction and patients with stable angina pectoris or compensated heart failure.<sup>3, 59</sup> It has been reported that heat therapy in patients with heart failure is associated with clinical improvements such as increased oxygen consumption, increased cardiac output, reduced systolic blood pressure, reduced peripheral resistance greatly, increased left ventricular ejection fraction, improved ventricular arrhythmias, and overall improvement in symptoms.<sup>37, 42, 50, 60</sup> There have been reports linking sauna baths with sudden death; however, these incidents have been shown to be at least partly due to alcohol consumption, which may have led to these accidents.<sup>61</sup> A combination of sauna bathing and alcohol consumption increases the risk of hypotension, cardiac complications, and traumatic events.<sup>59, 62</sup> However, the hot sauna exposure could potentially be harmful in patients with symptomatic and unstable disease conditions, such as unstable coronary artery disease.<sup>4</sup> Contraindications to sauna bathing have included individuals with unstable angina pectoris, recent myocardial infarction, uncontrolled hypertension, ischemic or decompensated heart failure, or severe aortic stenosis.<sup>3, 59, 63</sup> People with orthostatic hypotension or severe valvular disease should also exercise caution during the sauna bath because of possible sudden decreases in blood pressure, which may also occur during the recovery period after a sauna session.

Other possible contra-indications include fever, acute infectious or inflammatory conditions, and skin conditions such as abrasions and urticaria.<sup>26, 30</sup> A 7-year retrospective analyses of 598 burn patients treated in a major Finnish hospital revealed that about 26% of the cases were sauna-related burns.<sup>64</sup> Further analysis showed that majority of these burns were caused by accidental contact with the hot stove and steam; with 40% occurring under the influence of alcohol. Short stays in the sauna room combined with rapid cooling-off periods in cold water or shower is a common practice among sauna users. The health benefits and rationale for its use is not well known; however, it has been used among athletes who take a post exercise plunge into an ice bath and it is believed to enhance recovery, reduce muscle pain and soreness after the training sessions.<sup>65</sup> The practice of short sauna baths interrupted with rapid cooling-off is generally safe for healthy persons, but this may be associated with adverse reactions such as ventricular and atrial arrhythmias<sup>66, 67</sup> in patients with CVD and therefore it is not usually recommended.<sup>68</sup> Cold receptors in the skin are stimulated with this type of activity which increases production of catecholamines, such as noradrenalin, as a result of stimulation of the sympathetic nervous system.<sup>69</sup> There is subsequent vasoconstriction of skin vasculature, increased central volume, left ventricular end-diastolic pressure and volume, and stroke volume; which increases the work load of the heart making it hazardous for those with pre-existing CVD.<sup>68</sup>

In a study among young Finnish men, the plasma noradrenaline concentrations increased approximately twofold during the bath sessions with a mean temperature of 88 degrees C and mean duration of 22 minutes, whereas there were no significant changes in plasma adrenaline and serum thromboxane concentrations.<sup>70</sup> Although these hormonal changes have been documented, hot Finnish sauna and cold water immersion have been shown to be haemodynamically well tolerated without the occurrence of complex ventricular arrhythmias in patients with heart failure.<sup>11</sup> However, regarding wide recommendations to combine Finnish sauna with immediate cold-exposure in patients with unstable CVDs; due to the strong alteration in the human physiological responses between heat exposure and cold water immersion, there still remains possibility for sudden haemodynamic changes and risk of arrhythmias, especially among diseased patients with recent acute myocardial infarction.<sup>57</sup> Case fatalities have been recorded as a result of people diving head first into cold water right after a sauna

bath,<sup>71</sup> due to the constriction of the coronary arteries which decreases coronary blood flow and oxygen delivery to the heart.<sup>33</sup> There is a tendency toward enhanced ACTH and cortisol secretion and sympathetic activity by increased catecholamine secretion, which suggest that ice-cold immersion is a potentially harmful activity among those who are susceptible to hazardous cardiac arrhythmias and other CVD symptoms.<sup>72</sup> Therefore, large and well-designed studies are still needed among patients with pre-existing heart failure, CHD and cardiac arrhythmias to show if regular sauna bathing, combined with different kind of cooling down periods in various temperatures, is a safe activity.

### **Clinical implications**

There are established guidelines for the prevention and management of these acute and chronic disease conditions discussed in the preceding pages. This section is therefore not intended to recommend sauna bathing as a routine remedy for the treatment or prevention for these conditions, including major CVDs. Well-designed RCTs with long-term follow-up will still be needed to confirm if the observed associations reflect a true causal effect of frequent sauna bathing on these health conditions, and more studies are warranted to show if regular long-term sauna bathing could produce longer-term changes in cardiovascular health. In addition, available evidence is based on Finnish sauna baths with temperature settings around 80 °C. It is not known if saunas operating with lower temperatures or other passive heat therapies would yield similar cardiovascular effects and health benefits. This is a topic which requires further investigation.

Overall, the available data is made up of mixed quality evidence from mainly uncontrolled small intervention studies conducted several decades ago and observational study designs, which are limited by potential biases such as reverse causation and/or residual confounding (as with all observational designs). Though there is a possibility that factors such as physical activity and pre-existing disease could explain some of the findings in some of these observational designs; it is unlikely as most of these studies took into account these factors in their analyses and conducted sensitivity analyses to minimise the influence of these biases. Furthermore, our recent research evidence suggests that a combination of regular physical activity and sauna baths is associated with a substantial reduction in

the risk of fatal cardiovascular and all-cause mortality events compared with each modality alone.<sup>5, 16</sup> Our findings show that physical activity and sauna bathing each have independent effects on vascular disease, suggesting the likelihood that recent findings on the beneficial effects of sauna bathing on CVD is not due to physical activity or exercise. Despite the several limitations of previous study designs, the preceding evidence may be translated into clinical improvements. Indeed, based on the current knowledge and evidence, sauna bathing may have beneficial effects and has therapeutic potential to reduce the risk of adverse health outcomes in general population. In the future, sauna bathing has the potential to be also recommended for people with cardiovascular risk factors and stable cardiac patients as a pleasant lifestyle measure. However, further definitive research is needed. As with all newly started activities, it is prudent to start with caution, to check the individual tolerance, and increase the intensity and frequency of the activity gradually. In general, sauna bathing is a well-tolerated recreational activity, simple to use, enjoyable, does not involve physical exertion, and has a good safety profile<sup>3</sup>.

## **Conclusion**

Sauna bathing, an activity used for the purposes of pleasure, wellness and relaxation, is linked to a remarkable array of health benefits. It is a safe activity and can even be used in people with stable CVD, provided it is used sensibly for an appropriate period of time. Plentiful putative mechanistic pathways underlying these associations have been proposed, but many of these are not well understood. Further research work in the form of well-designed intervention studies is crucially needed to understand the pathophysiological mechanisms that underlie the associations between sauna bathing and its health benefits; establish any causal relevance to the associations; and whether these could be translated into clinical benefits. Sauna bathing may be a remedy to the call for additional lifestyle interventions needed to enhance health and wellness particularly in populations that have difficulty exercising and also as an adjunct to exercise.

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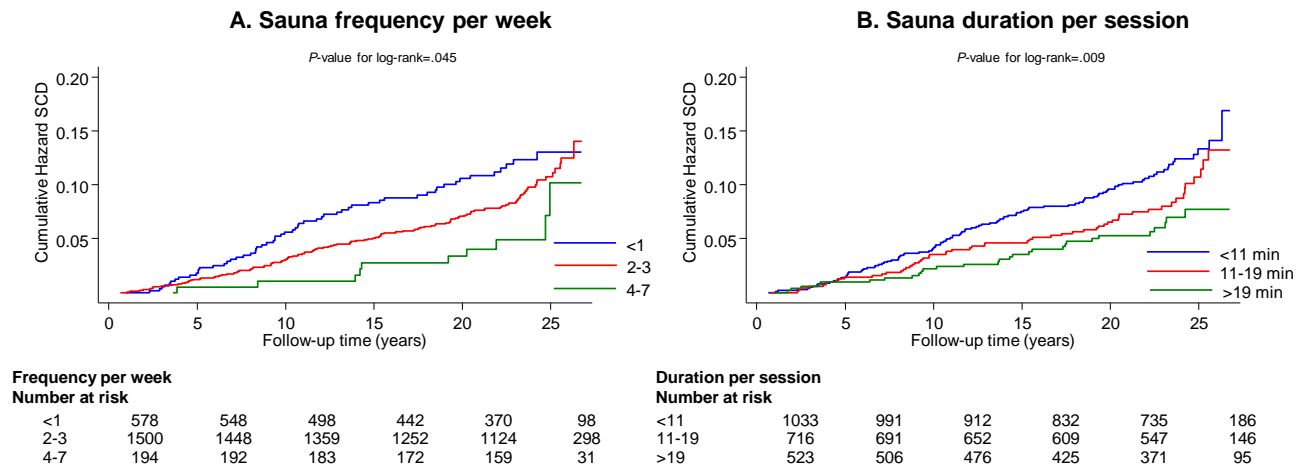
**Table.** Key prospective studies that have assessed the associations of sauna bathing habits with risk of acute and chronic disease conditions

Author, year of publication [reference]	Outcome	No. of participants	No. of cases	Risk ratio* (95% CI)	Risk comparison reported
Laukkanen T, 2015 [6]	CVD mortality	2315	407	0.50 (0.33-0.77)	4-7 vs 1 session/week
	CHD mortality		281	0.52 (0.31-0.88)	4-7 vs 1 session/week
	SCD		190	0.37 (0.18-0.75)	4-7 vs 1 session/week
	All-cause mortality		929	0.60 (0.46-0.80)	4-7 vs 1 session/week
Laukkanen T, 2017 [6]	CVD mortality	2315	407	0.76 (0.59-0.97)	> 19 vs 11 minutes
	CHD mortality		281	0.64 (0.46-0.88)	> 19 vs 11 minutes
	SCD		190	0.48 (0.31-0.75)	> 19 vs 11 minutes
	All-cause mortality		929	0.83 (0.87-1.20)	> 19 vs 11 minutes
Zaccardi F, 2017 [14]	Hypertension	1621	251	0.53 (0.28-0.98)	4-7 vs 1 session/week
Kunutsor SK, 2018 [15]	Stroke	1628	155	0.38 (0.18-0.81)	4-7 vs 1 session/week
	Ischemic stroke		129	0.42 (0.18-0.96)	4-7 vs 1 session/week
	Hemorrhagic stroke		34	0.33 (0.07-1.51)	4-7 vs 1 session/week
Laukkanen T, 2017 [19]	Dementia	2315	204	0.34 (0.16-0.71)	4-7 vs 1 session/week
	Alzheimer's disease		123	0.35 (0.14-0.90)	4-7 vs 1 session/week
Kunutsor SK, 2017 [23]	Respiratory diseases	1935	379	0.59 (0.37-0.94)	4-7 vs 1 session/week
Kunutsor SK, 2017 [24]	Pneumonia	2210	375	0.63 (0.39-1.00)	4-7 vs 1 session/week

\*, based on multivariate-adjusted analyses; CHD, coronary heart disease; CVD, cardiovascular disease; SCD, sudden cardiac death

**Figure legend**

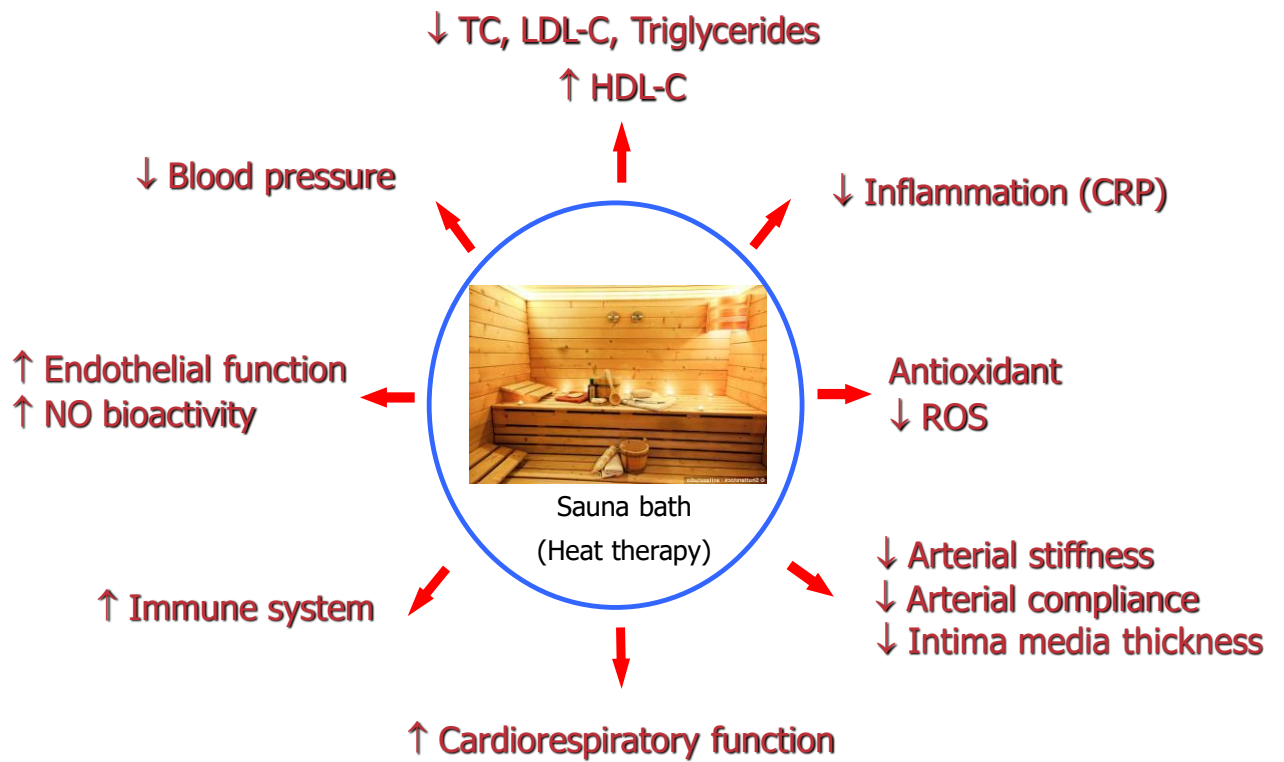
**Figure 1.** Cumulative Kaplan-Meier Curves for Sudden Cardiac Death According to Frequency and Duration of Sauna Baths



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A, Frequency of sauna bathing per week; B, Sauna duration per session

**Figure 2.** Pleiotropic Effects (Proposed Mechanistic Pathways) of Finnish Sauna Baths



CRP, C-reactive protein; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; NO, nitric oxide; ROS, reactive oxygen species; TC, Total cholesterol;