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SAUNA BATHING IN COMPETITIVE ATHLETES: BENEFIT OR RISK FOR RESPIRATORY AND IMMUNE FUNCTION? A NARRATIVE REVIEW

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ABSTRACT

Introduction: Sauna bathing has been investigated for its potential health and recovery effects, but its implications for respiratory and immune function in competitive athletes remain uncertain.

Objectives: This narrative review synthesizes current evidence on the respiratory and immunological effects of sauna bathing in competitive athletes, evaluating whether the practice constitutes a benefit or a risk in this population.

Materials and methods: A non-systematic literature search was conducted in PubMed, Scopus, and the Cochrane Library during August 2026. Experimental and observational studies, case reports, and review articles available in English or Polish were considered. Findings were synthesized narratively, distinguishing athlete-specific evidence from findings in other populations. No formal risk-of-bias assessment was performed.

Results: Sauna exposure can transiently alter circulating leukocytes, serum heat-shock proteins, and selected inflammatory mediators, but these responses do not establish improved immune defense. Related analyses of a Finnish population cohort associate frequent sauna bathing with lower respiratory disease incidence, without demonstrating causality or applicability to competitive athletes. Evidence for improved pulmonary function or prevention of respiratory infection in athletes is insufficient. Heat-acclimation and recovery findings address different outcomes. Potential risks include additional thermal and cardiovascular strain, fluid loss, and airway responses that depend on exposure conditions and individual susceptibility.

Conclusions: Sauna bathing may offer respiratory and immune benefits, but supporting evidence is largely indirect and derived from non-athlete populations. These benefits remain unconfirmed in competitive athletes. Controlled athlete-specific studies assessing respiratory symptoms, confirmed infections, immune function, and adverse events are needed to clarify the benefit–risk balance.

KEYWORDS

Sauna Bathing, Heat Therapy, Respiratory Function, Immune Function, Upper Respiratory Tract Infection, Athletes, Exercise Immunology

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1. Introduction

Sauna bathing is a traditional form of passive heat exposure that has been studied for decades for its potential health effects (Hannuksela & Ellahham, 2001; Kukkonen-Harjula & Kauppinen, 2006; Laukkanen et al., 2018). Analyses of the Finnish Kuopio Ischaemic Heart Disease (KIHD) cohort have reported associations between more frequent sauna bathing and a lower incidence of pneumonia and a combined respiratory disease outcome comprising pneumonia, asthma and chronic obstructive pulmonary disease (Kunutsor et al., 2017b, 2021, 2022; Kunutsor & Laukkanen, 2021). However, these observational findings do not establish that sauna bathing itself reduces respiratory disease risk. Furthermore findings in men aged 42–61 years at recruitment cannot be assumed to apply to competitive athletes.

Competitive athletes may face respiratory and immune challenges associated with intensive training and environmental exposure. Prolonged strenuous exercise can produce transient changes in immune cell distribution and function, historically interpreted as an “open window” of increased susceptibility to infection (Moreira et al., 2009; Nieman, 1994, 1995). However, whether these changes represent clinically meaningful immune suppression remains debated (Campbell & Turner, 2018). High ventilation rates during exercise in cold, dry air can promote airway cooling and dehydration (Kippelen et al., 2012), and high prevalence of asthma and airway hyperresponsiveness have been reported in cross-country skiers and other cold-air athletes (Bougault et al., 2009; Kippelen et al., 2012; Larsson et al., 1993). These observations provide the rationale for examining whether sauna bathing offers respiratory or immune benefits to competitive athletes and under what circumstances it may present additional risks. Sauna bathing also increases cardiovascular demands and causes sweating-related fluid loss (Hannuksela & Ellahham, 2001; Kukkonen-Harjula & Kauppinen, 2006). These responses warrant consideration when evaluating its use during post-exercise recovery.

Sauna research encompasses a range of outcomes, including neuromuscular performance, thermoregulation and hematological adaptations (Ahokas et al., 2023a; Mero et al., 2015; Pokora et al., 2021; Sitkowski et al., 2022a). These findings provide physiological context, but do not themselves establish benefits for respiratory or immune health. Similarly, changes in immune biomarkers should be distinguished from demonstrated clinical benefits, such as a reduction in respiratory infection risk.

The present narrative review examines sauna bathing specifically in relation to respiratory and immune function in competitive athletes. It distinguishes findings obtained directly in athletes from evidence derived from other populations and differentiates acute responses from adaptations to repeated exposure. Where evidence permits, sex and age are considered as potential modifiers of these responses. Limitations in population representation are also examined, including the documented underrepresentation of women in exercise thermoregulation research (Hutchins et al., 2021). The objective is to assess the potential benefits and risks of sauna bathing for respiratory and immune function in competitive athletes and identify priorities for further research.

2. Materials and methods

To examine the potential benefits and risks of sauna bathing for respiratory and immune function in competitive athletes, we conducted a non-systematic literature search in PubMed, Scopus, and the Cochrane Library. The final search was performed on 18 August 2026. Search terms included “sauna”, “sauna bathing”, “heat exposure”, “thermal stress”, “athletes”, “respiratory function”, “immune function”, “upper respiratory tract infection” and “exercise immunology” used in different combinations. No publication-year or language restrictions were applied during searching. However, publications without an available English- or Polish-language version were subsequently excluded because of practical language constraints.

All authors contributed to selecting publications according to their relevance to the review’s objectives. Study selection was not independently verified by a second reviewer. The literature considered included experimental and observational studies, surveys of sauna use, case reports relevant to adverse effects, and reviews providing broader context. Evidence from competitive athletes was distinguished from findings in

physically active adults, healthy non-athletes, and clinical or general-population samples. Studies in these other populations were included to address gaps in athlete-specific evidence. Animal studies and investigations of other heating methods were considered where they provided relevant mechanistic context, with limitations to their applicability explicitly acknowledged.

The synthesis focused on airway and pulmonary responses, respiratory symptoms and illness, leukocyte responses, heat-shock proteins, and inflammatory mediators. Studies of thermoregulation, cardiovascular responses, heat acclimation, recovery, and performance were included where they informed the physiological context or benefit–risk discussion. Traditional Finnish sauna, infrared sauna, and related forms of heat exposure were distinguished when interpreting findings.

Evidence was synthesized qualitatively by topic, considering study design, sample size, participant characteristics, exposure conditions, measurement timing, and applicability to competitive athletes. Acute responses were distinguished from adaptations to repeated exposure, and changes in physiological or immune biomarkers were not considered equivalent to demonstrated clinical benefits. Observational associations were distinguished from intervention effects, and reports from the same cohort were considered as related evidence rather than independent confirmation of the findings. No formal risk-of-bias assessment or meta-analysis was performed. The non-systematic search and selection process, lack of independent verification of study selection, and language-based exclusions may have introduced selection bias and limited the completeness of the review.

3. Sauna bathing as a thermal stressor

3.1 Sauna types and patterns of use among athletes

Sauna research involving athletes has focused primarily on traditional Finnish and infrared saunas, although the overall evidence base is small. In a 2025 systematic review of post-exercise heat exposure involving participants ranging from recreationally active adults to elite athletes, four of the six studies on sauna used a traditional sauna, whereas two used an infrared sauna (Ahokas, Hennessy, et al., 2025).

In a traditional Finnish sauna, a wood-burning or electric heater warms a bed of stones and the surrounding air. Temperatures typically range from 80 to 100°C at face level, with a relative humidity of approximately 10-20% (Hannuksela & Ellahham, 2001). Pouring water over the heated stones produces steam, temporarily increasing humidity. Conventional sauna bathing usually consists of 5-20-minute exposures, which may be repeated and separated by cooling periods (Hussain & Cohen, 2018). In the studies identified for this review, sauna protocols involving athletes have included three 8-minute exposures at 80-85°C and a single uninterrupted exposure averaging approximately 31 minutes at around 90°C (Ahokas, Hennessy, et al., 2025; Scoon et al., 2007). Cooling may involve resting at room temperature, showering, swimming, or cold water immersion. However, cold water exposure is not an obligatory component of Finnish sauna bathing, and cooling procedures vary across studies (Ahokas, Hennessy, et al., 2025; Hussain & Cohen, 2018).

Infrared saunas use electric emitters to deliver radiant heat at lower ambient temperatures than traditional Finnish saunas (Beever, 2009). Devices differ in their emission spectra, including far-infrared and full-spectrum cabins. Air temperatures are commonly described as approximately 40-60°C, however, measured conditions vary between devices and protocols (Ahokas et al., 2023a; Ahokas, Hanstock, et al., 2025; Beever, 2009). Although athlete-specific evidence remains limited, infrared sauna protocols have been investigated in some competitive team-sport athletes. In one study, 16 male basketball players competing in the second- and third-highest Finnish leagues underwent a 20-minute full-spectrum infrared sauna session after resistance exercise, at a measured air temperature of $43 \pm 5^\circ\text{C}$ and relative humidity of $21 \pm 1\%$ (Ahokas et al., 2023a). A subsequent study recruited 40 female basketball, futsal, ice-hockey and American football athletes competing in the highest to third-highest Finnish leagues. Participants assigned to the infrared sauna group completed 10-minute exposures after training, three times a week for six weeks. The sauna was set to 50°C, but the measured air temperature at hip level was $31.3 \pm 4.6^\circ\text{C}$, with a relative humidity of $48 \pm 10\%$ (Ahokas, Hanstock, et al., 2025).

Survey data can provide some insight into athletes' self-reported sauna use. A study by Menzies et al. found that 28% of 182 athletes who had previously used passive heating identified sauna as their principal heating method. Recovery was the most commonly reported purpose of passive heating, although this finding was not specific to sauna bathing (Menzies et al., 2023).

3.2 Systemic physiological responses to sauna bathing

Sauna bathing raises skin temperature and can potentially increase core temperature, depending on the exposure conditions (Gravel et al., 2019; Zalewski et al., 2014). Thermoregulatory responses include cutaneous vasodilation and sweating which contribute to heat dissipation. The resulting thermal strain depends on the heating method, temperature, humidity and exposure duration (Atencio et al., 2025; Kukkonen-Harjula et al., 1989). Higher humidity reduces the environment's capacity to support sweat evaporation and can increase heat strain (Che Muhamed et al., 2016).

The cardiovascular response to sauna bathing typically involves increases in heart rate and cardiac output, which help compensate for the reduction in systemic vascular resistance associated with cutaneous vasodilation (Atencio et al., 2025). Blood pressure responses can vary depending on the timing of measurement. In healthy adults, systolic and diastolic blood pressure have been observed to increase during sauna exposure and fall below baseline during subsequent recovery (Ketelhut & Ketelhut, 2019). Thus, a post-sauna reduction in blood pressure does not establish that blood pressure remained low throughout the session. Additionally, sauna bathing causes sweat-related fluid loss (Atencio et al., 2025). If these losses are not adequately replaced, hypohydration can develop and alter vascular function and blood pressure regulation (Watso & Farquhar, 2019).

Thermal stress also elicits neuroendocrine responses. Increased circulating noradrenaline concentrations have been reported during Finnish sauna bathing, consistent with sympathetic activation, whereas cortisol responses vary with exposure conditions and sampling time (Ježová et al., 1994; Kukkonen-Harjula et al., 1989). In one study, cortisol initially decreased during bathing before increasing later in the exposure and recovery period (Ježová et al., 1994). Alongside these neuroendocrine changes, sauna bathing has also been associated with changes in circulating heat-shock proteins. Increased serum HSP70 concentrations were observed after the first Finnish sauna session in trained and untrained men (Pilch et al., 2023). The relevance of heat-shock responses to immunity is addressed in Section 5.

Repeated sauna exposure may induce adaptations that reduce physiological strain during subsequent exercise in the heat. In trained middle-distance runners, three weeks of post-exercise sauna bathing reduced peak rectal temperature, skin temperature, and heart rate during a standardized heat-tolerance test compared with endurance training alone (Kirby, Lucas, Armstrong, et al., 2021). A separate small crossover study in six competitive male distance runners and triathletes reported plasma-volume expansion following three weeks of post-exercise sauna bathing compared with control training (Scoon et al., 2007). These findings support the potential for post-exercise sauna bathing to induce heat-acclimation adaptations, but do not establish equivalent effects for other sauna types or heating methods.

4. Sauna bathing and respiratory function

4.1. Airway and pulmonary responses

Sauna bathing may affect the respiratory system through whole-body heating and direct airway exposure to hot, humid air (Hayes et al., 2012; Kikuchi et al., 2013; Pandiaraja et al., 2022). The contribution of each mechanism depends on temperature, humidity, duration, ventilation, and baseline airway reactivity; dry sauna, steam bathing, and hyperventilation with hot humid air should therefore not be regarded as equivalent models (Hayes et al., 2012; Kikuchi et al., 2013; Mustafa, 2019; Pandiaraja et al., 2022). These differences may account for both modest changes in selected expiratory flows after repeated heating and transient bronchoconstriction after rapid airway heat delivery (Hayes et al., 2012; Kikuchi et al., 2013; Pandiaraja et al., 2022).

Spirometric changes measured after an exposure series do not define the acute bronchial response during an individual session (Hayes et al., 2012; Kikuchi et al., 2013; Pandiaraja et al., 2022).

Repeated passive heat exposure may modulate respiratory mechanics, but a consistent improvement in global pulmonary function has not been demonstrated. Waon therapy in stable chronic obstructive pulmonary disease was associated with a change in FEF50 but not FEV1 or FVC, whereas several spirometric indices improved after repeated steam bathing in healthy adults without a significant change in FEV1. This selective pattern does not establish sustained bronchodilation, greater ventilatory reserve, or enhanced respiratory performance. Proposed anti-inflammatory, vascular, and mechanical mechanisms were not directly assessed. Small non-randomized samples, the absence of a control group in the steam-bath study, and the lack of competitive athletes preclude considering sauna an established intervention for improving pulmonary function.

in athletes. Favorable changes in isolated indices should therefore be viewed as a signal of possible modulation, not evidence of a therapeutic or ergogenic effect (Kikuchi et al., 2013; Pandiaraja et al., 2022).

A different response may occur when a large thermal load reaches the airways during high ventilation. In mild stable asthma, hyperventilation with hot humid air increased airway resistance, reduced FEV1, and provoked cough, whereas the response in healthy participants was small. Prevention of bronchoconstriction by ipratropium despite persistent cough indicates a cholinergic bronchomotor reflex alongside independent sensory-nerve activation. Forced hyperventilation does not reproduce a typical sauna session, but it demonstrates the potential for heat-induced obstruction in inflamed or hyperresponsive airways (Hayes et al., 2012). Susceptibility may therefore depend more on effective airway thermal dose and respiratory phenotype than on ambient temperature alone (Hayes et al., 2012; Hsu et al., 2013; Lee et al., 2011; Lin et al., 2015).

Thermosensitive vagal bronchopulmonary C-fibers link airway heating with cough and bronchoconstriction (Hsu et al., 2013; Lee et al., 2011; Lin et al., 2015). TRPV1 channels on these endings can be sensitized by increasing temperature, promoting cough, mucus secretion, and reflex airway narrowing (Lee et al., 2011). Inflammation increases sensory excitability and may explain the stronger thermal response in asthma and allergic airway inflammation (Hayes et al., 2012; Hsu et al., 2013; Lin et al., 2015). In animal models, inspired-air warming enhanced C-fiber activity and pulmonary resistance mainly after allergen sensitization, while rapid recovery indicated reversible neural sensitization rather than thermal injury (Hsu et al., 2013; Lin et al., 2015). Cholinergic reflexes, tachykinins, and a direct smooth-muscle response may all contribute, although species differences and experimental models limit mechanistic translation (Hayes et al., 2012; Hsu et al., 2013; Mustafa, 2019).

These mechanisms support phenotype-dependent susceptibility but do not establish that sauna exposure is generally harmful (Hayes et al., 2012; Hsu et al., 2013; Lee et al., 2011; Lin et al., 2015; Mustafa, 2019).

Favorable and adverse respiratory responses to heat reflect different routes of heat transfer and airway phenotypes (Hayes et al., 2012; Hsu et al., 2013; Kikuchi et al., 2013; Lee et al., 2011; Lin et al., 2015; Mustafa, 2019; Pandiaraja et al., 2022). Repeated whole-body heating during quiet breathing may promote systemic adaptation and modest flow changes, whereas rapid airway heating during high ventilation may transiently increase airway resistance, particularly in asthma or airway hyperresponsiveness (Hayes et al., 2012; Hsu et al., 2013; Kikuchi et al., 2013; Lee et al., 2011; Lin et al., 2015; Pandiaraja et al., 2022). The response is shaped by temperature, humidity, ventilation, exposure modality and duration, and baseline airway status (Hayes et al., 2012; Hsu et al., 2013; Kikuchi et al., 2013; Lee et al., 2011; Lin et al., 2015; Mustafa, 2019; Pandiaraja et al., 2022). The studies discussed here do not establish the effects of sauna bathing on pulmonary function or bronchoconstriction risk in competitive athletes. (Hayes et al., 2012; Kikuchi et al., 2013; Pandiaraja et al., 2022). Sauna-related respiratory effects should therefore be considered context dependent rather than uniformly beneficial or harmful (Hayes et al., 2012; Hsu et al., 2013; Kikuchi et al., 2013; Lee et al., 2011; Lin et al., 2015; Mustafa, 2019; Pandiaraja et al., 2022).

Any performance benefit of sauna bathing cannot presently be attributed to improved pulmonary function (Kikuchi et al., 2013; Pandiaraja et al., 2022).

4.2 Respiratory symptoms and clinical outcomes

Clinical evaluation of sauna bathing requires prevention to be distinguished from treatment and adverse events related to the facility environment (Ernst et al., 1990; Huang et al., 2010; Kunutsor et al., 2017b, 2017a; Pach et al., 2010; Umehara et al., 2008). Habitual use may be associated with lower respiratory morbidity, whereas short-term exposure has not treated acute infection (Ernst et al., 1990; Kunutsor et al., 2017b, 2017a; Pach et al., 2010).

A small controlled study associated sauna bathing once or twice weekly for six months with fewer common colds and symptomatic days, but not with shorter or milder episodes. The difference emerged after several months, suggesting altered susceptibility rather than symptomatic relief. Non-random allocation, the small sample, self-reported symptoms, and unconfirmed etiology limit this inference (Ernst et al., 1990).

In a randomized trial, three days of hot dry air inhalation did not reduce cumulative severity of a newly acquired common cold. Brief inhalation through a mask did not reproduce conventional sauna bathing but provided no support for hot air as symptomatic treatment (Pach et al., 2010). Putative prevention should therefore not be equated with efficacy during established infection (Ernst et al., 1990; Pach et al., 2010).

In the KIHD cohort, more frequent sauna bathing was associated with fewer hospital-diagnosed respiratory diseases, including pneumonia. The composite and pneumonia analyses involved the same Finnish cohort, and the composite association disappeared when death was treated as a competing event. Single

baseline assessment, residual confounding, and hospital-only diagnoses preclude causal inference or conclusions about mild infections and missed training. These observations remain hypothesis-generating and do not justify preventive recommendations (Kunutsor et al., 2017b, 2017a).

Evidence in chronic pulmonary disease is similarly limited. Following four weeks of Waon therapy in 13 patients with severe chronic obstructive pulmonary disease, SGRQ scores and exercise tolerance improved, whereas MRC dyspnea grade did not. The uncontrolled design, small sample, and far-infrared modality prevent extrapolation to healthy athletes using Finnish sauna. Waon therapy therefore remains an experimental adjunct in stable disease (Umehara et al., 2008).

Facility-related symptoms may also reflect biological exposure. Repeated steam-bath visits were linked to hypersensitivity pneumonitis caused by *Exophiala jeanselmei*. A single case cannot quantify risk but emphasizes hygiene, ventilation, and bioaerosol control (Huang et al., 2010).

Sauna bathing has no established efficacy for treating an acute common cold or shortening respiratory symptoms (Ernst et al., 1990; Pach et al., 2010). Possible protection against future illness rests on a small controlled study and repeated analyses of one cohort (Ernst et al., 1990; Kunutsor et al., 2017b, 2017a). None of the studies discussed in this subsection enrolled competitive athletes or assessed laboratory-confirmed infection, missed training, asthma exacerbations, or return to sport. Sauna should therefore not be presented to athletes as established respiratory prophylaxis or therapy (Ernst et al., 1990; Huang et al., 2010; Kunutsor et al., 2017b, 2017a; Pach et al., 2010; Umehara et al., 2008).

4.3 Sport-specific and modality-specific respiratory considerations

Evaluation of sauna use in sport requires adaptation induced by repeated exposure to be distinguished from recovery after a single session. A 2025 systematic review included 14 studies and 194 participants, but combined traditional sauna, infrared sauna, and hot-water immersion, while acute findings were beneficial, neutral, or adverse depending on the protocol and endpoint. Every included study raised at least some risk-of-bias concerns, and small samples, male predominance, and heterogeneous training status limited generalizability. Sauna should therefore be regarded as a specific heat stimulus rather than a uniform performance or recovery intervention (Ahokas, Hennessy, et al., 2025).

The strongest signal of benefit concerns repeated sauna bathing after endurance training (Kirby, Lucas, Armstrong, et al., 2021; Scoon et al., 2007). In 20 trained middle-distance runners, three weeks of exposure improved exercise tolerance in the heat and selected laboratory markers in temperate conditions, including VO₂max and speed at a blood lactate concentration of 4 mmol/L (Kirby, Lucas, Armstrong, et al., 2021). Participants self-selected their groups, only 20 of 51 recruits completed the study, and competition performance was not assessed, leaving the ergogenic effect uncertain (Kirby, Lucas, Armstrong, et al., 2021). In a crossover study of six runners, three weeks of sauna increased run time to exhaustion and plasma volume relative to the control period, but the estimated time-trial improvement was an indirect calculation and the protocol lacked baseline measurements before each period (Scoon et al., 2007). These findings support possible heat adaptation but do not establish a reproducible improvement in sporting performance (Ahokas, Hennessy, et al., 2025; Kirby, Lucas, Armstrong, et al., 2021; Scoon et al., 2007).

Plasma-volume expansion is a plausible but inconsistent mediator (Pokora et al., 2021; Scoon et al., 2007; Sitkowski et al., 2022a; Stanley et al., 2015). In seven trained cyclists, its largest increase occurred after four of ten exposures, but performance was not tested and relationships with autonomic indices were unclear (Stanley et al., 2015). In a study of 14 elite cross-country skiers, with selected hematological analyses available for 10 participants, a series of ten sauna sessions produced a modest and highly variable increase in resting plasma volume, a lower resting heart rate, and only limited thermoregulatory adaptation, without a control group or performance endpoint (Pokora et al., 2021). Importantly, a randomized crossover study of 13 physical education students found no additional benefit of sauna over training for hemoglobin mass, intravascular volumes, or exercise capacity despite fluid restriction (Sitkowski et al., 2022b). A change in plasma volume therefore cannot serve as surrogate proof of an ergogenic effect (Ahokas, Hennessy, et al., 2025; Pokora et al., 2021; Scoon et al., 2007; Sitkowski et al., 2022a; Stanley et al., 2015).

Evidence for acute recovery is even more divergent (Ahokas et al., 2023b; Ahokas, Hennessy, et al., 2025; Skorski et al., 2020). In 20 young swimmers and triathletes, traditional sauna after intensive training impaired 4 x 50-m performance the following morning versus placebo; 15 athletes performed worse, and perceived stress was higher (Skorski et al., 2020). Conversely, in 16 basketball players, 20 minutes of infrared sauna attenuated the loss of jump height and muscle soreness after resistance exercise but did not improve sprinting, isometric strength, sleep, or nocturnal autonomic recovery (Ahokas et al., 2023a). The opposite

directions cannot be attributed to sauna technology alone because the studies differed in sport, loading, heat dose, and assessment timing and did not directly compare modalities (Ahokas et al., 2023a; Ahokas, Hennessy, et al., 2025; Skorski et al., 2020).

Regular infrared sauna likewise has not shown a general anabolic or neuromuscular effect. After six weeks of training in female team-sport athletes, it did not augment hypertrophy or most sprint, strength, and power outcomes; signals of benefit were confined to one loaded-jump condition and early sprint acceleration. Thirty-six participants remained in the analysis, pair matching was used instead of randomization, and air temperature at hip height was approximately 31°C despite a 50°C setting, indicating a modest and incompletely characterized heat dose (Ahokas, Hanstock, et al., 2025). Infrared-sauna findings should therefore not be transferred automatically to Finnish sauna (Ahokas et al., 2023a; Ahokas, Hanstock, et al., 2025; Ahokas, Hennessy, et al., 2025).

Post-exercise exposure adds to total training and heat load (Ahokas, Hennessy, et al., 2025; Skorski et al., 2020; Yokoyama et al., 2026). Sweating, vasodilation, and relative hypovolemia may promote dehydration, syncope, heat illness, and renal or electrolyte disturbances, although clinical evidence combines several forms of acute heat exposure and does not quantify their incidence in athletes (Yokoyama et al., 2026). A protocol should first be tested outside competition, individualized to tolerance and training schedule, and accompanied by hydration and symptom monitoring; an intensive unfamiliar exposure should not precede a key session or competition (Ahokas, Hennessy, et al., 2025; Skorski et al., 2020; Yokoyama et al., 2026). Repeated post-exercise sauna may support heat adaptation and selected endurance markers, but it is not an established universal ergogenic or recovery method. None of these studies demonstrated that any performance improvement was mediated by better pulmonary function or respiratory clinical outcomes (Ahokas et al., 2023a; Ahokas, Hanstock, et al., 2025; Ahokas, Hennessy, et al., 2025; Kirby, Lucas, Armstrong, et al., 2021; Pokora et al., 2021; Scoon et al., 2007; Sitkowski et al., 2022a; Skorski et al., 2020; Stanley et al., 2015).

5. Sauna Bathing and Immune Function

5.1. Acute Leukocyte Responses and Cell Redistribution

A single session of Finnish sauna bathing transiently increases circulating leukocyte counts, although the duration and biological significance of this response remain uncertain. In a recent study of 51 middle-aged adults, total leukocyte counts increased immediately after a 30-minute sauna session in both men and women (Heinonen et al., 2026). Thirty minutes later, counts had returned to baseline in men but remained slightly elevated in women. The response differed among leukocyte subtypes. Lymphocyte counts increased immediately in both sexes and were no longer significantly different from baseline after 30 minutes, whereas a significant neutrophil increase was observed only in women. The mixed-cell fraction, comprising monocytes, eosinophils, and basophils, increased immediately after sauna in men but not in women, and was not significantly elevated above baseline during recovery (Heinonen et al., 2026). These findings indicate a brief, sex-dependent redistribution of circulating leukocytes rather than a uniform or sustained leukocytosis.

Mean plasma volume did not change during the experiment, and the blood measurements were additionally corrected for individual plasma-volume shifts. Hemoconcentration is therefore unlikely to account fully for the observed changes. Leukocyte mobilization was not associated with the increase in tympanic temperature, suggesting that the response was not determined solely by the measured rise in body temperature (Heinonen et al., 2026). The study did not include a non-heated control condition or assess leukocyte function, however, and its findings should be interpreted as evidence of transient cell mobilization rather than improved immune competence.

Limited athlete-specific evidence points to a possible influence of training status. In trained middle-distance runners and untrained men exposed to the same sauna protocol, athletes showed larger increases in total leukocyte and monocyte counts, together with greater losses of body mass and plasma volume (Pilch et al., 2013). The small sample and marked differences between this protocol and the more recent study make direct comparisons difficult. Catecholamine-mediated demargination and redistribution of leukocytes, similar to that observed during exercise, is one possible explanation (Sand, 2013), but the mechanism has not been examined directly during sauna bathing. Although this transient mobilization may contribute to enhanced immune surveillance, its functional significance and its effect on susceptibility to infection have not yet been established.

5.2. HSP70 Response and Heat Adaptation

Heat shock protein 70 has distinct intracellular and extracellular functions. Within cells, HSP70 acts as a molecular chaperone that assists protein folding and limits the accumulation of damaged or misfolded proteins. Extracellular HSP70 can instead function as a damage-associated signal and influence innate immune pathways (Asea, 2008). Changes in serum HSP70 should therefore not be treated as a direct measure of intracellular chaperone activity or cellular repair. Repeated Finnish sauna exposure has been shown to induce significant increases in serum HSP70 concentrations (Pilch et al., 2023).

In a study of trained and untrained young men, serum HSP70 increased after Finnish sauna exposure, without a clear difference in the magnitude of the response between the groups (Pilch et al., 2023). The increase recorded after the tenth sauna session was smaller than that observed after the first session. This attenuation coincided with a lower thermal strain during the later exposure and was interpreted as a possible sign of adaptation to repeated heat stress (Pilch et al., 2023). It remains uncertain whether the altered HSP70 response reflected physiological acclimation, a lower internal heat dose, or both.

The observed HSP70 response is consistent with heat adaptation, but its importance for athletic recovery remains uncertain. No study has yet shown that sauna induced changes in circulating HSP70 accelerate tissue repair, improve subsequent performance, or reduce the risk of infection in competitive athletes. A recent umbrella review of recovery strategies in elite winter sports athletes also found that sauna bathing has not been evaluated in dedicated systematic reviews or meta analyses focused on post exercise recovery. The limited available evidence was inconsistent, and one study reported impaired swimming performance, possibly because the sauna added further thermal strain after exercise (Edholm et al., 2024). The term “cytoprotective” is therefore appropriate when referring to the established intracellular functions of HSP70, but it should not be presented as a proven effect of sauna bathing on recovery or clinical outcomes.

5.3. Cytokine Responses and Markers of Systemic Inflammation

Acute cytokine responses to Finnish sauna bathing are less consistent than the changes observed in circulating leukocytes. In the study examining 37 cytokines and related inflammatory mediators, only soluble CD30 and pentraxin-3 changed significantly after the sauna session, with both concentrations decreasing. Matrix metalloproteinase-2 showed a borderline increase (Heinonen et al., 2026). Several cytokine changes correlated with the rise in tympanic temperature, but these correlations did not translate into a broad or uniform increase in circulating cytokine concentrations.

A crossover study in healthy middle-aged and older adults suggested that the response may depend on exposure duration. Interleukin-6 increased after two 10-minute sauna periods but not after a single period, whereas IL-1 receptor antagonist increased following both protocols and CRP remained unchanged (Behzadi et al., 2020). A small study of trained and untrained young men also reported acute increases in IL-6 and IL-10 after sauna exposure (Pilch et al., 2023).

These findings have been compared with the cytokine response to exercise, particularly the increase in muscle-derived IL-6 followed by the release of anti-inflammatory mediators (Pedersen & Febbraio, 2008). This comparison requires caution because the cellular source of IL-6 during passive heat exposure is unknown, and sauna studies have not demonstrated the complete cytokine sequence observed after prolonged exercise. An isolated increase in IL-6 therefore cannot be classified as either pro-inflammatory or anti-inflammatory (Rose-John, 2012).

Long-term observational evidence suggests an association with lower systemic inflammation. In the KIHHD cohort, frequent sauna bathing was cross-sectionally associated with lower hsCRP and leukocyte count, whereas the association with fibrinogen was not statistically significant. At the 11-year follow-up, inverse associations were observed for all three inflammatory markers, while no association was found with GGT, which was used as a marker of oxidative stress (Kunutsor et al., 2018). Residual confounding cannot be excluded, and whether these findings apply to competitive athletes remains unknown.

5.4. Respiratory Outcomes in Population and Controlled Studies

Evidence linking sauna bathing with respiratory illness comes mainly from Finnish population studies. In the KIHHD study, men who reported two to three or at least four sauna sessions per week had a lower incidence of pneumonia than those using a sauna no more than once weekly (Kunutsor et al., 2017a). A separate analysis of the same cohort found an inverse association between sauna frequency and a composite respiratory outcome including pneumonia, asthma, and chronic obstructive pulmonary disease (Kunutsor et al., 2017b). The graded associations suggest a possible dose response relationship, however sauna use was self-reported

and residual confounding by physical activity, fitness, socioeconomic circumstances, and other health behaviors cannot be excluded. Both analyses also involved predominantly middle aged Finnish men from the same cohort, limiting their generalizability.

Controlled evidence is limited to a small study of 50 volunteers followed for six months. Participants assigned to regular sauna bathing experienced fewer common colds than controls, with the difference becoming more apparent during the second half of follow up (Ernst et al., 1990). Nevertheless, limited methodological reporting, the small sample, and the absence of confirmatory trials reduce confidence in this finding.

Habitual sauna bathing may therefore be associated with fewer respiratory illnesses in general populations, but current evidence does not establish causality or demonstrate prevention of respiratory infection in competitive athletes.

5.5. Relevance to the “Open Window” Debate in Competitive Athletes

The “open window” hypothesis suggests that prolonged strenuous exercise causes a temporary period of impaired host defense and increased susceptibility to upper respiratory tract infection. This interpretation was based on postexercise reductions in circulating lymphocytes, natural killer cell activity, neutrophil function, and salivary IgA (Kakanis et al., 2010; Nieman, 1997).

The hypothesis remains controversial. More recent evidence suggests that the decline in circulating lymphocytes largely reflects redistribution to peripheral tissues rather than systemic immune suppression, while changes in salivary IgA do not consistently predict subsequent illness (Campbell & Turner, 2018). Many studies have also relied on self-reported respiratory symptoms, which do not necessarily indicate confirmed infection and may instead reflect airway irritation, allergy, exercise-induced bronchoconstriction, or noninfectious inflammation (Spence et al., 2007).

This debate is relevant to sauna use after exercise. Sauna bathing mobilizes circulating leukocytes and alters HSP70 and selected cytokines, but it is unknown whether these responses modify the postexercise immune response or affect infection susceptibility. There is currently no direct evidence that sauna either reduces or increases this proposed period of vulnerability.

The more immediate concern is the additional physiological strain. Sauna exposure increases thermal and cardiovascular load and promotes further sweating when athletes may already be dehydrated or overheated. No controlled study has compared exercise alone with exercise followed by sauna while assessing immune cell function, mucosal immunity, and subsequent respiratory illness. Until such evidence is available, the effects of sauna use after strenuous exercise on immune recovery and infection risk in competitive athletes remain uncertain.

6. Discussion

6.1 Evidence for potential benefits

The strongest argument for a beneficial effect of regular sauna bathing on the respiratory system comes from data from the Finnish Kuopio Ischaemic Heart Disease Risk Factor Study (KIHD) cohort. In a long-term follow-up of adult men, more frequent sauna use was associated with a significantly lower risk of respiratory disease, including chronic obstructive pulmonary disease, asthma, and pneumonia, with a dose–response relationship - the more frequent the sauna sessions, the stronger the protective effect (Kunutsor et al., 2017b). Although this study was conducted in a general population rather than athletes, it provides the most compelling long-term epidemiological evidence for a potential association of sauna bathing with an effect on the respiratory tract.

From a sport-specific perspective, work on passive heat acclimation is particularly relevant. A review by Heathcote et al. indicates that sauna use, hot-water immersion, and environmental chambers, as passive heat-stress strategies, can successfully induce thermoregulatory, cardiovascular, and perceptual adaptations, improving exercise capacity in endurance athletes (Heathcote et al., 2018). This mechanism may have indirect relevance for respiratory and immune resilience, as adaptation to heat stress partly overlaps with the physiological pathways activated by exercise training.

Intervention studies in athletic populations support the practical application of this concept. In trained middle-distance runners, repeated post-exercise sauna sessions carried out over several weeks improved markers of exercise capacity in both hot and temperate conditions (Kirby, Lucas, Armstrong, et al., 2021). Similarly, in young semi-professional footballers, several weeks of passive acclimation to extreme heat in a

dry sauna led to improvements in physical performance and physiological indices (Bartolomé et al., 2021). While these studies focused primarily on performance and heat-acclimation outcomes rather than immune or respiratory endpoints, they demonstrate that repeated controlled heat exposure can induce physiological adaptations in athletes. Whether these adaptations translate into improved immune function, greater resistance to respiratory infection, or enhanced immune recovery after intensive training remains unknown.

A recent systematic review of post-exercise heat exposure found heterogeneous and inconclusive effects on acute recovery, with beneficial, neutral, and adverse outcomes depending on the protocol and outcome assessed. Repeated heat exposure showed some evidence of favorable training adaptations, particularly for endurance performance under hot conditions; however, the overall evidence was limited by small sample sizes, methodological heterogeneity, and risk-of-bias concerns (Ahokas, Hennessy, et al., 2025).

Taken together, the available evidence points to a two indirect lines of evidence: a long-term epidemiological effect of reduced risk of respiratory infection and disease with regular sauna bathing in the general population, and short- to medium-term physiological adaptations observed in athletes undergoing repeated heat exposure, which may indirectly support the body's resilience to the physiological demands of intensive training.

6.2 Risks, adverse effects, and contraindications

Alongside its purported benefits, sauna bathing carries a recognized profile of acute physiological risks that are particularly relevant for competitive athletes, whose sauna use is typically superimposed on an already elevated baseline of thermal and cardiovascular strain from training.

Hannuksela and Ellahham, in a comprehensive review of the physiological effects of sauna bathing, note that although sauna is well tolerated by most healthy individuals, it induces marked acute cardiovascular and hormonal changes, and identify severe aortic stenosis, unstable angina, and recent myocardial infarction as absolute contraindications, with decompensated heart failure and significant arrhythmia as relative contraindications. They also highlight that alcohol consumption substantially increases the risk of hypotension, arrhythmia, and loss of consciousness during heat exposure, and that most sauna-related deaths occur inside the sauna itself, frequently in the context of alcohol intoxication (Hannuksela & Ellahham, 2001). For athletes, these findings highlight the importance of avoiding alcohol around sauna sessions and exercising particular caution in individuals with known cardiovascular disease, relevant symptoms, or other medical risk factors. In such cases, individual medical assessment may be appropriate before additional heat exposure is incorporated into the training routine.

Kukkonen-Harjula and Kauppinen's literature review similarly emphasizes that most existing evidence derives from uncontrolled studies in habituated bathers, and that caution is warranted when extrapolating to individuals with chronic disease, those on certain medications, or in special physiological states such as pregnancy (Kukkonen-Harjula & Kauppinen, 2006). This methodological caveat is directly relevant to the athletic literature, where small sample sizes and heterogeneous protocols (as noted even in benefit-focused reviews) limit firm safety conclusions specific to trained populations.

A further body of evidence concerns sudden cardiac death. Laukkanen and Kunutsor's review addressed whether sauna bathing is protective or hazardous with respect to sudden cardiac death, concluding that, in the general population, habitual sauna use appears more often protective than harmful, but also acknowledging that acute sauna exposure transiently increases heart rate and cardiac workload in a manner resembling moderate-intensity exercise (Laukkanen & Kunutsor, 2019). For competitive athletes, stacking this cardiovascular load on top of intense training sessions - rather than using sauna as an isolated, well-recovered exposure - could theoretically compound cumulative strain, particularly in the context of pre-existing dehydration.

This is where risk considerations specific to sport become most pertinent. Athletes entering a sauna in a hypohydrated or electrolyte-depleted state following training or competition may be more susceptible to additional thermal and cardiovascular strain.; established sports-medicine guidance stresses that inadequate fluid and electrolyte replacement, along with recent illness or a prior history of heat illness, are key risk factors for recurrent heat-related events (Casa et al., 2015). Combining post-exercise sauna use with insufficient rehydration may therefore blunt rather than support recovery. Practical injury risks associated with sauna facilities themselves - burns, slips, and falls in wet, hot environments - have also been documented and are relevant wherever shared team facilities are used (Kaiser et al., 2023).

Taken together, these sources suggest that risk in the athletic context is less about sauna bathing per se and more about context: pre-existing cardiac vulnerability, alcohol use, inadequate hydration and electrolyte repletion after training, and the cumulative physiological load of combining heat stress with an already demanding training program.

6.3 Factors modifying the benefit–risk balance

The balance between benefit and risk associated with sauna bathing in competitive athletes is not fixed - it depends on a range of protocol-related factors, individual characteristics, and training context, all of which can shift this balance in either direction.

A key modifying factor is the heat acclimation protocol itself - its intensity, duration, and frequency. A systematic review and meta-analysis by Rahimi et al. showed that the magnitude of adaptations to heat acclimation depends on factors such as intervention duration, environmental conditions, and training protocol, with substantial heterogeneity across studies limiting the formulation of universal recommendations (Rahimi et al., 2019). Périard, Racinais and Sawka, in their review of heat acclimation mechanisms in athletes, similarly emphasize that the rate and extent of adaptation depend on variables such as baseline training status, existing degree of acclimatization, and sport-specific characteristics - endurance athletes, who already display some heat-adapted features as a result of training alone, may derive smaller additional gains from sauna exposure than non-acclimatized individuals (Périard et al., 2015).

Practical feasibility within the context of elite sport is another important modifying factor. Casadio et al.'s review notes that although evidence-based guidelines for heat acclimation are clear, their implementation often conflicts with the time constraints and training priorities of elite athletes. The authors highlight uncertainty about the extent to which additional heat stress (sauna, hot-water immersion) adds to an athlete's already existing training load - a consideration directly relevant to the benefit–risk balance, since the same intervention may be beneficial during a lower-volume preparatory phase but detrimental during intensive competition blocks (Casadio et al., 2017).

Sex is a further factor that differentiates the response to sauna bathing. A study by Kirby et al. in trained middle-distance runners found that a three-week program of post-exercise sauna bathing effectively induced heat acclimation in both women and men, though likely via different thermoeffector mechanisms - suggesting a need to individualize protocols by sex rather than mechanically extrapolating recommendations derived mainly from male samples (Kirby, Lucas, Cable, et al., 2021).

To these should be added practical elements relevant to safety: the timing of sauna use relative to training and competition (sauna immediately before an event may deepen dehydration and increase heat-illness risk, whereas sessions during a recovery period, with adequate hydration, appear safer), the athlete's hydration and electrolyte status before entering the sauna, prior heat exposure and habituation (regular sauna users likely tolerate exposure better than novices), and the characteristics of the sport itself - in weight-category sports, where sauna is sometimes used for rapid pre-weigh-in mass reduction, the risk of heat illness and electrolyte disturbance is substantially higher than when sauna is used as a routine element of post-training recovery.

Taken together, these factors indicate that the question "is sauna beneficial or risky for an athlete" is incomplete without specifying: which protocol, in which athlete, at what point in the training cycle, and in what hydration state - these are the variables that determine which way the benefit–risk balance tips.

6.4 Limitations of the current evidence

The evidence discussed in this review is subject to several important limitations that should be kept in mind when drawing practical conclusions for competitive athletes.

A substantial portion of the strongest epidemiological evidence comes from observational studies conducted in general populations rather than in athletes. Generalizing these findings to younger individuals with a different physiological profile, a different level of training, and different patterns of exposure to infectious agents is inherently limited. A further problem lies in the observational, rather than experimental, nature of these studies, which precludes firm conclusions about causality. Individuals who bathe regularly in saunas may simply differ from those who do not in terms of other health-related behaviors, representing a potential source of confounding that these study designs cannot fully rule out.

Moreover, the literature focusing directly on athletes concentrates almost exclusively on performance and physiological markers, such as heat acclimation or plasma volume, rather than on hard endpoints related to respiratory function or immunity. Conclusions about a potential immunological effect are therefore largely indirect, inferred from physiological mechanisms rather than directly measured as a clinical outcome. This picture is further complicated by the small sample sizes and short follow-up periods typical of the available intervention studies. Such constraints limit statistical power and the ability to detect rarer, yet clinically meaningful, effects, and they leave open the question of how durable any potential benefits might be over the longer term.

Interpretation is also hindered by considerable heterogeneity in the protocols used. Differences in temperature, humidity, session duration, frequency, and the timing of sauna use relative to training make it difficult to compare results across studies or to formulate consistent, precise dosing recommendations. Recent systematic reviews have highlighted substantial heterogeneity and uncertainty in the available evidence, limiting the strength of conclusions regarding the effects of sauna bathing and other post-exercise heat-exposure strategies. There also appears to be a tendency toward publishing predominantly positive findings, and this may have skewed the overall body of literature toward overestimating the true magnitude of benefit.

Female athletes remain substantially underrepresented in the available literature as well, since most studies, both epidemiological and interventional, have been conducted in men. This limits the extent to which sex-specific recommendations can currently be formulated with confidence. Finally, there is a near-total absence of randomized trials that directly measure the hard endpoints most relevant to the topic of this review, such as the incidence of upper respiratory tract infections, within competitive athlete populations specifically. Most conclusions concerning this particular question therefore remain, by necessity, speculative, and they call for dedicated, long-term prospective studies conducted directly in this group.

6.5 Recommendations for future research

To address the gaps identified in the limitations above, future research should first focus on competitive athletes as a distinct study population, rather than relying primarily on extrapolation from general population findings to inform practical recommendations. Prospective cohort studies and randomized trials conducted directly among athletes across a range of sports would be particularly valuable if they adopted hard clinical endpoints as their primary outcome, such as the incidence of upper respiratory tract infections, the number of days lost to illness, or the frequency of training interruptions caused by infection, rather than relying solely on indirect physiological or performance markers.

Standardizing the research protocols used would also be important, so that findings can be meaningfully compared and pooled in future meta-analyses. This calls for precise reporting of heat exposure parameters, including temperature, humidity, session duration and frequency, as well as the timing of sauna use relative to training and competition. Studies should aim to establish a clear dose–response relationship, which would allow specific, practically applicable recommendations to be formulated rather than general statements about potential benefit.

A further priority should be increasing sample sizes and extending follow-up periods, which would make it possible both to detect rarer yet clinically meaningful effects and to assess the durability of any adaptations over a longer horizon, ideally spanning full competitive seasons. At the same time it is essential to include more female athletes in future studies and to examine potential sex differences in the response to heat exposure, rather than assuming that findings derived from male samples can be directly extrapolated to women.

It would also be valuable to combine mechanistic studies assessing immunological and inflammatory markers, such as heat shock proteins, cytokines, or lymphocyte subpopulations, with simultaneous measurement of actual clinical outcomes. This would help verify whether the observed biochemical changes genuinely translate into a measurable improvement in immune resilience. Future studies should likewise take into account the specifics of different phases of the training cycle and the differing demands of individual sports, including weight category sports, where the risks associated with sauna use may be particularly elevated.

Finally, given the practical time and logistical constraints faced by competitive athletes, future research should evaluate not only the physiological effectiveness of particular protocols but also their real world feasibility within an actual training and competition cycle, so that findings can be effectively translated into practical guidance for coaches, sports physiologists, and athletes themselves.

7. Conclusions

Current evidence is insufficient to determine whether sauna bathing improves respiratory and immune health in competitive athletes. Sauna exposure can alter circulating leukocytes, heat-shock proteins, and inflammatory mediators, but these changes do not demonstrate improved immune defense or reduced infection risk. Associations between habitual sauna bathing and lower respiratory disease incidence arise mainly from general-population studies and cannot be assumed to apply to athletes. Similarly, heat-acclimation adaptations following repeated sauna exposure should be distinguished from respiratory or immune benefits. Potential risks relate to additional thermal and cardiovascular strain, fluid loss, and individual susceptibility, although their magnitude in athletic settings remains poorly defined. The benefit–risk balance therefore requires consideration of exposure conditions, training context, hydration, and underlying health. Controlled studies in competitive athletes assessing respiratory symptoms, confirmed infections, immune function, and adverse events are needed before sauna bathing can be recommended specifically to support respiratory and immune health.

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