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Sauna, the Cardiovascular System and Autonomic Regulation: Implications for Post-exercise Recovery – A Narrative Review of the Literature

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ABSTRACT
Introduction. Sauna bathing, traditionally associated with relaxation in Nordic countries, is increasingly regarded as a tool supporting cardiovascular prevention and post-exercise recovery. As its use becomes more widespread, questions arise about the safety of this form of heat exposure, the mechanisms by which it affects the cardiovascular system and autonomic

regulation, and how it can be integrated into training programmes for athletes and physically active individuals.

Aim. The aim of this narrative review is to organize current knowledge on the acute and chronic effects of sauna bathing on haemodynamic parameters, sympathetic–parasympathetic balance and post-exercise recovery, with particular emphasis on potential benefits, risks, contraindications and practical aspects of dosing the thermal stimulus.

State of knowledge: Available studies indicate that a single sauna session induces predictable circulatory changes – peripheral vasodilation, an increase in heart rate and cardiac output with a moderate reduction in arterial blood pressure, and transient hypovolaemia. Regular sauna bathing has been associated in long-term observations with a more favourable cardiovascular profile, improvement in selected indices of sinus rhythm variability, better subjective well-being and improved exercise tolerance. In athletic populations, sauna may support the perception of recovery, promote muscle relaxation and facilitate glycogen resynthesis, provided that it is used with adequate attention to hydration and appropriate dosing of heat stress.

Conclusions. Sauna appears to be a valuable and relatively simple adjunct to cardiovascular prevention strategies and recovery programmes, but it does not replace physical activity or causal treatment. Further interventional studies are needed to refine optimal protocols of sauna bathing in the general population and in elite sport, and to better define groups in whom the benefits outweigh the risks.

Keywords: sauna, cardiovascular system, autonomic regulation, heart rate variability, post-exercise recovery, athletes

1. Introduction

For many decades, sauna bathing has been an integral element of the culture of Northern European countries, where it is perceived not only as a form of relaxation but also as a health-promoting practice embedded in everyday routines [1,2,25,26]. Traditionally, it functions as a space for social encounters, a purifying “ritual” and a kind of reset after a day of work. In many Nordic communities, visiting the sauna is a habit passed down from generation to generation, and the very notion of “health” is often closely intertwined with regular exposure to thermal

stimuli, interspersed with short cooling periods.

In recent years, with the development of recreational infrastructure and the popularization of healthy lifestyle patterns, sauna bathing has increasingly expanded beyond regions with a long-standing tradition of Finnish baths [2,4,25,26]. It has become accessible to broad segments of the population, including sedentary individuals, elite athletes and patients participating in cardiac rehabilitation programmes. In many fitness clubs, swimming pools and wellness centres, a sauna cabin is now part of standard facilities. Not infrequently, it constitutes the central point of the so-called wellness zone, where it is accompanied by hot tubs, steam rooms, contrast showers and relaxation areas.

This widespread availability generates a number of questions that reach general practitioners, cardiologists and sports medicine specialists [3,4]. Patients with cardiovascular diseases want to know whether sauna bathing is safe for them, under what conditions it can be used as a form of "heat training" and whether it can realistically reduce the risk of recurrent events [1,2,3,4,8]. Athletes and coaches ask whether incorporating high-temperature exposure into a training plan truly accelerates recovery, reduces delayed onset muscle soreness and improves tolerance of subsequent exercise sessions [10,11,18,21,27]. Such questions are increasingly articulated also by recreationally active individuals who wish to combine regular training with elements of recovery but lack accessible, reliable information on the physiological effects of sauna use.

In clinical practice and informal conversations with patients, certain ideas about sauna recur with striking regularity – from the belief that it is a "safe way to replace exercise" to the conviction that it allows for almost magical "sweating out toxins"[1,2,25,26]. On the one hand, this shows how deeply rooted the intuitive belief in the health-promoting properties of heat is; on the other, it highlights how limited the real contact with solid physiological knowledge remains. It is precisely this discrepancy between the lay image of sauna bathing and scientific data that became one of the impulses for the present review.

In popular media, simplified narratives clearly prevail. Sauna is often depicted as an almost universal method of "detoxifying" the body – a vague concept loaded with numerous myths [1,2,25,26]. Some sources stress supposed "toxin removal through sweat", while others focus exclusively on pleasure and relaxation, downplaying safety aspects and contraindications. It is rarely emphasized that the thermal stimulus, despite being pleasant, represents a genuine haemodynamic load for the body and requires the activation of complex adaptive responses. Such dissonance between popular messaging and scientific knowledge makes informed decision-making difficult for both patients and clinicians.

It should also be noted that the increasing interest in sauna bathing in recent years does not stem

solely from wellness trends, but also from very practical needs of users seeking simple, repeatable methods to support metabolic and cardiovascular health [3,4,25,26,27]. In conversations with patients, the motif of an intuitive "sense of relief" after a heat session recurs, which is not always easy to capture in studies yet appears with such consistency that it cannot be ignored [1,2,25,26,27]. It is this combination of scientific data, individual experience and clinical observation that creates the context in which sauna emerges as a topic worth in-depth analysis. Although some reports prompt caution, everyday practice shows that users rarely perceive sauna as a mere whim, but rather as a tangible element of their routine self-care.

The aim of this review is to present in a structured way the physiological foundations of the body's response to heat stress in the sauna, to discuss the acute and chronic effects of this intervention on the cardiovascular system and autonomic regulation, and to analyse available data on the use of sauna for post-exercise recovery. The text is a narrative review and reflects mainly clinical experience as well as experimental and observational data. Rather than producing categorical recommendations, the author seeks to organize the most important themes and to indicate areas in which everyday practice clearly "overtakes" the strength of current evidence.

2. Methods of literature selection

This paper is deliberately written as a narrative review. Instead of calculating pooled effect estimates in a formal meta-analysis, it assembles the most relevant themes from the literature and discusses them from a clinically oriented perspective. Literature selection was based on searches in databases indexing biomedical publications, with particular attention given to interventional studies on sauna exposure, long-term observational data in populations using sauna regularly, and studies analysing sinus rhythm variability and haemodynamic parameters [3,4,6,7,10,11]. Narrative and opinion reviews were also considered if they contributed substantially to conceptual clarification, as were selected experimental studies in the fields of exercise physiology and thermoregulation [18,20,21,27].

Both studies involving healthy individuals and those including cardiac patients or elite athletes were taken into account. Special attention was paid to differences in heat exposure protocols, since temperature, humidity, session duration and intervals between sessions strongly determine the nature of the cardiovascular load. Whenever possible, classic Finnish sauna was distinguished from steam baths and infrared saunas, although in some publications terminology was used inconsistently, which itself constitutes a potential source of interpretative bias.

Because of the narrative design, no formal risk-of-bias scoring system was applied, nor were

pooled measures of effect calculated. Emphasis was placed instead on the coherence of conclusions and transparent description of the limitations of individual studies. Methodological constraints such as small sample sizes, lack of control groups, short observation periods and population heterogeneity were explicitly highlighted. The goal was to sketch a cohesive picture of the direction and potential relevance of observed effects, rather than to formulate definitive high-level evidence-based recommendations.

During the analysis of the literature, an interesting discrepancy emerged between experimental findings and the accounts of individuals who use sauna regularly. Many users emphasize effects that are not always clearly documented in the scientific literature yet recur with surprising consistency. This discrepancy argues for combining qualitative research with classical measurement-based approaches, as individual experience often reveals subtle aspects of adaptation that escape standard analytical tools. For this type of narrative work, paying attention to both strands of evidence is not an ornament but a practical necessity.

3. Physiology of the response to heat stress in the sauna

3.1. Thermoregulation and circulatory load

Sauna bathing, especially in the Finnish type, involves brief but intense exposure to elevated ambient temperature, usually at moderate air humidity [1,2]. The first line of response is the thermoregulatory system, tasked with maintaining core temperature within a narrow physiological range. An increase in skin and superficial tissue temperature is detected by peripheral thermoreceptors, and the signal is transmitted to hypothalamic structures, which integrate information on the thermal status of the body and initiate effector responses.

One of the key reactions is cutaneous vasodilation, which increases blood flow through superficial skin layers and facilitates heat dissipation from the core to the environment [2,9,23]. Vasodilation is accompanied by enhanced sweating. Evaporation of sweat from the skin surface consumes considerable energy, further limiting the rise in core temperature. In hot, dry air this mechanism is highly effective; under conditions of high humidity its efficiency falls markedly, which in part explains poorer tolerance of steam rooms in some individuals.

Peripheral vasodilation carries important haemodynamic consequences. A substantial shift of blood volume to the cutaneous vascular bed leads to a relative reduction in venous return and lower ventricular filling pressure. To maintain adequate cardiac output, reflex tachycardia and a modest increase in myocardial contractility occur. In a normally functioning cardiovascular system, a new equilibrium is achieved, characterized by a higher heart rate, slightly reduced arterial blood pressure and increased flow through the skin circulation, which is usually well

tolerated.

As the session continues, fluid loss due to sweating progressively increases. Body mass losses in the range of one to two percent during a single heat exposure are not uncommon, particularly if baseline hydration is suboptimal or the session is prolonged and not accompanied by planned fluid intake [2,22,23,24]. The result is a reduction in plasma volume and an increase in haematocrit and blood viscosity. The combination of vasodilation and hypovolaemia constitutes the main burden on the cardiovascular system and explains well the occurrence of dizziness, a sense of "lightheadedness" or weakness after leaving the sauna cabin, especially when changing from a seated to a standing position abruptly [2,9,23].

In outpatient practice it is easy to observe that patients rarely link such episodes directly to dehydration and redistribution of blood to the skin. More often, they interpret them as a "heart attack" or "sudden blood pressure spikes", which further heightens anxiety and may encourage avoidance of activity. Only a detailed explanation of the physiological mechanism tends to help them view these complaints in a less catastrophic way.

3.2. Hormonal response and chronic adaptation

In parallel, a series of endocrine mechanisms is activated. Rising temperature and dehydration stimulate the secretion of vasopressin, renin and aldosterone, promoting water and sodium retention in the hours following the session [2,23,24]. Increased concentrations of catecholamines, cortisol and thyroid hormones have also been observed, particularly in the acute phase of heat stress. Over the longer term, repeated heat exposure may, however, lead to partial "economization" of hormonal responses and better tolerance of environmental stress, analogous to exercise-induced adaptation.

Mechanisms underlying this process include gradual expansion of plasma volume, improved endothelial function, more efficient vascular reactivity and modulation of the hypothalamic–pituitary–adrenal axis [12,22,24]. In clinical and sports practice, this means that over time, individuals who use sauna on a regular basis experience less tachycardia at a given thermal load and perceive heat discomfort as less intense. In essence, this pattern mirrors the heat acclimation described in athletes preparing for competition in hot climates. In everyday practice, clinicians often notice that such adaptation appears earlier in patients who already pay attention to hydration or have some experience with interval-type training.

3.3. Effects of sauna on other organ systems

The response to heat stress is not restricted to the cardiovascular and autonomic nervous systems [2,9,23]. Changes also occur in the respiratory tract, kidneys, skin and central nervous

system. Increased heart rate often coexists with a moderate rise in respiratory rate intended to increase heat exchange through the airways. In some individuals with bronchial hyperreactivity, hot, dry air may provoke discomfort, while in others it subjectively improves the sensation of airway patency, particularly when sauna use follows exercise and associated hyperventilation. Clinicians who work closely with endurance athletes often hear that these seemingly minor respiratory sensations strongly colour how ready the athlete feels for the next day's session. What is striking is that such comments are reported even by people with completely normal spirometry and no objective signs of airway disease. This kind of everyday observation is a useful reminder that standard physiological measurements capture only part of what matters for post-exercise recovery.

At the renal level, a transient reduction in diuresis is observed during and immediately after the session, related to the action of vasopressin and the renin–angiotensin–aldosterone system [2]. Later, after fluid balance has been restored, compensatory polyuria may occur, particularly if large volumes of fluid are ingested in a short time after the heat exposure. From a practical standpoint, this is relevant in patients with chronic kidney disease and in individuals using diuretics, where abrupt changes in circulating blood volume may aggravate exercise intolerance.

In some users, neuropsychological components play a major role. Elevation of body temperature, a sense of isolation from external stimuli, dim lighting and the repetitive ritual of entering and leaving the cabin favour a state of calm. This may partly explain the reported improvements in mood and sleep quality, independently of haemodynamic effects. Some studies emphasize that regular sauna bathing often forms part of a broader "recovery-oriented lifestyle", in which physical activity and sleep hygiene coexist with relaxation rituals [4,25,26,27].

4. Inter-individual differences in response to heat stress

Clinical and experimental observations alike show that the response to heat stress varies considerably between individuals. Young individuals without chronic disease and with good physical fitness typically tolerate even relatively high thermal loads well, adapting within a few sessions [2,4,22]. In older patients with reduced cardiovascular reserve or coexisting autonomic dysfunction, for example in the context of diabetes, the risk of heat intolerance is considerably higher.

Baseline physical activity and body mass also matter. Individuals with obesity dissipate heat less effectively through the skin, which promotes faster increases in core temperature [22,23,24,28]. In some, tolerance of high temperatures is clearly reduced and may require

shorter exposure times or the use of lower benches. By contrast, well-trained individuals with high cardiorespiratory fitness often display more efficient vascular responses and faster adaptation to repeated heat stimuli.

Cultural and environmental factors are also significant [1,2,25,26,27]. Organisms accustomed to frequent heat exposure respond differently from those that encounter sauna only sporadically. People raised within "sauna cultures" often feel comfortable with longer sessions and higher temperatures, but such patterns should not be automatically transferred to beginners, particularly those with chronic disease. For physicians and coaches, this means that seemingly simple questions about previous sauna experience should be part of the history, and not only questions about comorbidities.

5. Types of sauna and the importance of exposure parameters

Although the term "sauna" is commonly used in the singular, in practice several types of heat bathing exist, differing in temperature, humidity and characteristics of the thermal stimulus. Classic Finnish sauna is based on dry heat at high temperatures, with a periodic brief increase in humidity when water is poured onto hot stones [1,2,25,26]. This alternating pattern – very hot dry air interrupted by short episodes of higher humidity – produces a variable yet predictable thermoregulatory response.

Steam rooms operate at lower temperature but much higher humidity, which alters heat dissipation and may be less well tolerated by individuals with respiratory disease [1,2,9]. Under such conditions, evaporation of sweat is less effective and the body relies more on conduction and convection. Users experience the air as "heavier" and more oppressive, and for a similar thermal load subjective discomfort may be more pronounced.

In recent years, infrared saunas have also gained popularity. In these devices, direct tissue heating by radiation plays a greater role, while air temperature remains relatively lower. For some users, particularly those with respiratory disorders, this form of exposure is more comfortable, although its haemodynamic and autonomic profile may differ from that of classical Finnish sauna.

From the perspective of the cardiovascular and autonomic nervous systems, not only the type of sauna but also the details of the session are important [2,4,9,22]. Total exposure time, the number of "heat–cooling" cycles, the height of the bench on which the user sits and breaks between entries together determine the overall thermal load. Interventional studies typically apply protocols with several short entries separated by rest and hydration, in order to limit the risk of marked hypovolaemia and abrupt drops in blood pressure. In recreational settings,

protocols are much less standardized, which partly explains the diversity of experiences and observed effects.

In everyday practice, users rarely pay attention to bench height, although a difference of several to a dozen or so degrees Celsius between floor level and the top benches translates into a markedly different cardiovascular load. A cardiac patient choosing the highest bench may experience a much stronger stimulus than someone staying on the lowest level with shorter exposure. From a safety standpoint, this seemingly minor detail is clinically relevant and should be included in educational advice.

6. Effects of sauna on the cardiovascular system – acute and chronic

The most immediate outcome of sauna bathing is a change in haemodynamic parameters during a single session [1,2,3,4,6,9,23]. Heart rate typically increases to values corresponding to moderate-intensity exercise, and cardiac output rises in response to vasodilation and the need to maintain adequate perfusion. Systolic blood pressure usually decreases slightly or remains close to baseline values, whereas diastolic pressure tends to fall more consistently. As a result, mean arterial pressure declines, while blood flow in the skin circulation and coronary vessels increases.

In individuals with preserved cardiovascular reserve, this “heat load” is sometimes compared to low-to-moderate-intensity aerobic exercise. Enhanced peripheral flow, transient volume overload and cyclic baroreceptor activation constitute a stimulus for vascular and cardiac adaptation. Studies in which participants used sauna several times per week over a period of months reported reductions in resting blood pressure, improvements in endothelial function indices and favourable changes in indices of arterial stiffness, which may contribute to lower cardiovascular risk [3,4,6,7,8,25].

Increased coronary blood flow observed in some studies is interpreted as a consequence of both vasodilation and higher myocardial oxygen demand. In the absence of advanced atherosclerotic lesions, such an increase in flow is usually well compensated. In patients with significant coronary artery disease, however, responses may differ, especially when heat exposure coincides with dehydration and tachycardia. Recommendations therefore emphasize the need for gradual introduction of sauna in this group, preferring lower temperatures and shorter sessions. Data from large Finnish cohort studies suggest that regular sauna bathing is linked with a lower incidence of fatal cardiovascular events [3,6,7]. These observations need to be interpreted with caution, because people who use sauna frequently also tend to be more physically active, smoke less and pay more attention to diet. Even careful statistical adjustment

cannot fully disentangle these overlapping behaviours. Nevertheless, the association persists after partial adjustment, which raises the possibility that sauna itself may contribute to risk reduction, particularly in the areas of hypertension and stable coronary artery disease.

On the other hand, the additional haemodynamic load imposed by heat stress may exceed adaptive capacity in patients with severe aortic stenosis, unstable coronary disease or advanced heart failure [1,2,8,23,31]. Standing up rapidly after a prolonged session, especially in the setting of dehydration, increases the risk of orthostatic hypotension and vasovagal syncope [2,9,23]. This is particularly relevant for older individuals taking antihypertensive or diuretic medications and for those with limited cardiovascular reserve. In such patients, uncontrolled sauna exposure may trigger an adverse event rather than serve as a preventive measure.

It should be emphasized that even within the same diagnostic group, haemodynamic responses can differ in ways that are difficult to predict. Clinicians often note that some patients' reactions are distinctly different from textbook patterns, which calls for caution when formulating overly general recommendations. For example, some patients report improved exercise tolerance after regular sauna bathing despite an absence of clear changes in laboratory parameters. While such observations cannot replace population-based studies, they provide valuable complementary information [3,4,6,7].

Table 1. Acute and chronic cardiovascular effects of sauna bathing

Domain	Acute effects (single session)	Chronic effects (regular use)
Heart rate and cardiac output	Increase in heart rate to values comparable with moderate aerobic exercise; rise in cardiac output driven by vasodilation	Lower resting heart rate in some users; improved cardiac efficiency reported in observational data
Blood pressure	Slight decrease in systolic pressure; more consistent reduction in diastolic pressure; fall in mean arterial pressure	Gradual reduction in resting blood pressure, particularly in individuals with hypertension
Vascular system	Peripheral vasodilation; redistribution of blood to cutaneous circulation	Improved endothelial function; favourable changes in arterial stiffness indices
Blood volume and hydration	Sweating-induced plasma volume reduction; transient hypovolaemia	Expansion of plasma volume with repeated exposure;

		improved tolerance of heat stress
Coronary circulation	Increase in coronary blood flow due to vasodilation and elevated myocardial oxygen demand	Potential reduction in risk of fatal coronary events reported in observational cohorts (interpretation with caution)
Symptoms / tolerance	Possible dizziness, orthostatic intolerance, "lighteadedness" sensation, especially with abrupt standing	Better heat tolerance, milder tachycardic response, reduced perception of thermal discomfort
Autonomic balance	Transition from sympathetic activation during heating to vagal predominance during cooling	Improved selected HRV indices; possible normalization of autonomic balance in stress-prone individuals

7. Sauna, autonomic regulation and heart rate variability

Over roughly the last decade, several groups have attempted to characterise how sauna influences sympathetic–parasympathetic balance, most often by analysing heart rate variability (HRV) [10,12,13,14]. Adequate, high HRV reflects a flexible, well-functioning autonomic nervous system capable of rapid adaptation to changing environmental demands [13,14,15,16]. Reduced variability, especially with a predominance of sympathetic activity, is associated with a higher risk of adverse cardiovascular events and poorer prognosis in many chronic diseases.

Short-term studies performed immediately after sauna sessions have demonstrated marked increases in parameters reflecting parasympathetic activity, such as the high-frequency component of HRV spectra and prolongation of mean RR intervals during rest [10,12]. This pattern may be interpreted as a transition from a state of heightened sympathetic drive during the heating phase to a state of vagal predominance during cooling and relaxation. Subjectively, this manifests as a feeling of calm, drowsiness and "quieting down" after the session.

With regular sauna bathing over weeks or months, some studies indicate a sustained improvement in selected HRV indices, which may suggest normalization of autonomic balance [10,12,16]. This phenomenon may be particularly relevant in individuals with chronic stress, hypertension or metabolic syndrome, in whom sympathetic predominance and reduced HRV are common. In such cases, sauna may act as a form of "adaptive training", with the body

practising transitions from arousal to relaxation in controlled conditions.

HRV analysis, however, is notoriously sensitive to context: time of day, hydration, recent sleep and even caffeine intake can all distort the picture if they are not carefully controlled [13,14]. Some discrepancies in the literature may therefore stem from methodological differences rather than true absence of effect. In practice, interpretation of HRV findings in the context of sauna bathing calls for humility, and sweeping conclusions should not be drawn from single parameters alone.

8. Sauna in post-exercise recovery

In most sporting environments, athletes and coaches talk about sauna first and foremost as a recovery tool [11,12,18,21,27]. After intense training or competition, many athletes use it in the belief that higher temperature will accelerate the return of functional capacity, reduce muscle soreness and facilitate sleep. Some of these beliefs have a physiological basis, while others arise mainly from habit, tradition or subjective experience.

Immediately after exercise, muscle tissue is characterized by increased metabolite production, microdamage to fibres and transient disturbances in water–electrolyte balance [18,19,21,23]. An increase in tissue temperature and peripheral vasodilation during a sauna session may accelerate blood flow and thereby enhance the removal of metabolites and the delivery of energy substrates, including glucose needed for glycogen resynthesis [11,12,18,23,24]. This potential effect will, however, be most apparent if heat exposure is combined with appropriate fluid and carbohydrate replacement.

Conversations with both elite and recreational athletes often reveal the perception that it is not the sheer duration or temperature of the session that matters most, but the way it is “embedded” within the training day [18,20,21,27,29]. Athletes frequently stress that even a short, but predictable and consistent evening sauna session helps them “structure” the post-training period more effectively than elaborate yet irregular recovery rituals. This user perspective, although difficult to capture in standard research protocols, seems important when interpreting findings on subjective recovery. Several coaches informally note that when athletes describe a ‘good recovery day’, their comments rarely refer to laboratory metrics but instead to very concrete sensations, such as easier breathing on stairs or reduced limb heaviness. In discussions with athletes, another recurring element concerns the almost ritualistic importance of maintaining the same sequence of post-training actions. For some, deviating from this routine — even if physiologically irrelevant — creates a sense of unease that can itself shape the perception of recovery quality. These nuances rarely find their way into formal studies, yet in high-

performance settings they often play a disproportionate role.

The subjective dimension itself is also relevant. Warmth and a sense of being enveloped promote reduced muscle tension, often experienced as “relaxation” and alleviation of pain. Staying in a quiet, isolated environment helps many athletes switch from a mode of competition and mobilization to a mode of recovery. A stable ritual of ending the training day with a sauna session can function as a signal to the body that the intense phase of activity is over, which facilitates sleep onset and improves sleep quality.

Conversely, a poorly designed sauna protocol may paradoxically hinder recovery [11,18,19,21,23]. If an athlete enters a long, very hot session immediately after exercise, in a state of dehydration and depleted glycogen stores, exercise-induced and heat-induced hypovolaemia overlap and stress hormone levels rise further. Under such conditions, muscle perfusion may be impaired and repair processes slowed. Prolonged thermal load may also disturb sleep if the session is conducted late in the evening and ends without a gradual cooling phase.

In practice, sauna is best used as a second stage of recovery, following initial cooling, gentle stretching and fluid and carbohydrate replenishment [11,18,21,22,24]. Sessions should be of moderate duration, with breaks in a cooler environment and systematic rehydration. In endurance sports and in athletes with high training loads, it may be advisable to limit heat exposure to lower-intensity days or to use lower temperatures and shorter entries. In strength and power disciplines, sauna may be used more frequently, but basic principles of exercise and recovery hygiene must still be respected.

Experience from working with athletes suggests that the perception of recovery can be as important as its objective markers [18,20,21,27,29]. Many competitors emphasize that sauna helps them “close the training day”, giving structure to the rhythm of load and rest. This dimension is not easy to quantify, yet in professional sport, where psychological stress is a constant companion, seemingly minor ritual signals may significantly influence readiness to perform. In this sense, sauna serves not only a biological function but also a regulatory one, helping to organize the day’s structure.

9. Psychological and behavioural dimensions of sauna use

Most earlier studies on sauna concentrated on haemodynamic and autonomic mechanisms, but in everyday practice psychological and behavioural aspects are often just as visible, and only recently have they started to attract more systematic attention [4,18,20,21,27]. The experience of heat exposure, although rooted in measurable physiological responses, is embedded in a

wider context that includes personal rituals, cultural norms, expectations and subjective interpretations of bodily sensations. These aspects often shape the user's relationship with sauna at least as strongly as cardiovascular reactions, yet they remain insufficiently described in the scientific literature.

A recurring theme in interviews with regular sauna users is the perception of the session as a temporal "boundary", demarcating the transition from the demands of daily functioning to a state of intentional rest. This boundary is not created by heat alone; rather, it is the combination of elevated temperature, silence or muffled sounds, dim lighting and the repetitive routine of entering and exiting the cabin that creates a highly structured environment conducive to psychological decompression. For many individuals, this environment becomes a consistent anchor around which their recovery practices are organized.

From a behavioural standpoint, sauna often functions as an external regulator of daily rhythm [18,20,21,27]. People who struggle with maintaining sleep hygiene, especially those engaged in intense intellectual or physical activity, report that the predictability of an evening sauna session makes it easier for them to detach from stimulation and prepare for rest. Interestingly, this effect does not always align with objective sleep measurements but exerts a significant influence on subjective rest quality. The interplay between expectation, ritual and bodily sensations may, in some individuals, be as relevant as the direct physiological effects of heat exposure.

Another dimension concerns the sense of agency [20,21,27]. Individuals with chronic cardiovascular conditions frequently experience a reduction in perceived control over their bodies. The ability to use sauna safely—under supervision and within a clear framework—may serve as a rehabilitative experience, reinforcing the feeling of regained autonomy. This psychological benefit, though difficult to quantify, should not be dismissed as anecdotal. In behavioural medicine, such experiences may meaningfully support long-term adherence to therapeutic recommendations.

Cultural context further shapes psychological responses to sauna [1,2,25,26]. In societies where sauna has a long tradition, users often approach it with a sense of familiarity and continuity. In other cultures, sauna use may be perceived as novel, aspirational or even intimidating. These differences influence not only subjective comfort but also the willingness to experiment with different temperatures, exposure lengths and recovery practices.

A topic requiring greater scientific attention is the phenomenon of "social facilitation". Informal observations suggest that many individuals—especially beginners—tolerate heat better or feel more at ease during sauna sessions when accompanied by a more experienced user. The

presence of another person reduces uncertainty, enhances the sense of safety and minimizes ruminative focus on bodily sensations. These mechanisms resemble those described in social support models within stress research, yet have not been systematically investigated in the context of heat exposure.

Taken together, the psychological and behavioural layer of sauna use constitutes a field with significant explanatory and practical potential. Understanding these aspects may improve patient education, optimize recovery routines for athletes and inform the design of rehabilitation programmes that integrate thermal stimulation with behavioural interventions.

10. Sauna within integrated recovery and training frameworks

Current thinking about recovery in both sport and preventive cardiology is moving away from single techniques towards integrated routines that combine several physiological and behavioural interventions [4,17,18,21,31]. Within such frameworks, sauna occupies a specific, though flexible, role. It may serve as a bridge between physical exertion and rest, complement contrast therapies, coexist with cold-water immersion, or enhance the effects of breathing exercises and mindfulness-based techniques.

One conceptual model proposes viewing sauna as part of a “three-phase recovery arc” [18,21,27]. The first phase involves the immediate post-exercise window, dominated by cooling, hydration and normalization of autonomic arousal. The second phase comprises the structured thermal exposure itself, administered with careful attention to session length, temperature and hydration status. The final phase includes post-sauna rest, during which parasympathetic predominance may consolidate and subjective recovery gains become more pronounced. Athletes who follow such routines often report clearer thinking and less perceived fatigue the next day, even if objective performance indicators change only slightly.

Another approach treats sauna as a component of environmental stress conditioning [22,24]. Just as altitude training or controlled cold exposure can modulate metabolic and autonomic pathways, repeated heat exposure may stimulate adaptive processes that translate into improved performance or resilience. For endurance athletes, this may include enhanced plasma volume, improved sweat response efficiency and greater tolerance of training in warm weather [12,17,22,24]. In sports requiring rapid recovery between sessions or matches, sauna may contribute indirectly by reinforcing sleep routines and reducing cumulative psychophysiological stress.

In preventive cardiology, integrated programmes that combine sauna, moderate aerobic activity, dietary changes and structured patient education appear promising [3,4,25,28,30,31].

What emerges from clinical observations is not a single “synergistic effect” but rather a subtle accumulation of benefits arising from improved vascular function, enhanced autonomic balance, better adherence to behavioural recommendations and reduced stress-related symptoms. Patients frequently report that the incorporation of sauna into their weekly schedule makes the entire programme feel more coherent and manageable.

A particularly understudied area concerns the interaction between sauna use and cognitive function [5]. Preliminary reports suggest that combining heat exposure with deliberate relaxation or mindfulness practices may amplify improvements in attentional control and emotional regulation. The heat appears to facilitate disengagement from external stimuli, creating conditions favourable for structured mental training. While speculative, this observation aligns with broader findings on the neurocognitive effects of rituals and environmental modulation.

For coaches and clinicians, the practical implication is that sauna should not be viewed as an isolated technique but as one element within a larger system of behavioural and physiological interventions. When integrated appropriately, sauna may enhance programme adherence, support long-term habit formation and reinforce health-promoting behaviours. Future research should examine not only physiological outcomes but also the structure and consistency of routines that incorporate sauna as part of a wider training or rehabilitation architecture.

11. Clinical applications and safety of sauna use

Although sauna is commonly associated with recreation, it is increasingly considered as an adjunct in rehabilitation and prevention of chronic diseases [3,4,7,8,25,26,27,28,31]. In patients with mild to moderate hypertension, regular sauna sessions may contribute to a gradual reduction in blood pressure, improved endothelial function and increased exercise tolerance [3,4,6,7,8,25]. In individuals with metabolic syndrome, potential improvements in insulin sensitivity and reductions in low-grade inflammation have been noted, although evidence remains limited and does not yet justify unequivocal therapeutic recommendations [4,7,30,31].

In cardiac rehabilitation, sauna is occasionally considered as a supplement to conventional exercise training, particularly in patients who have difficulty performing mechanically loaded activity [8,12,28,31]. Short-term increases in cardiac output and vasodilation may partially mimic the effects of gentle exercise at lower musculoskeletal strain. In this group, however, the principle of gradual introduction under medical supervision applies, with careful observation of tolerance.

Discussions with patients enrolled in cardiac rehabilitation programmes reveal that some of

them perceive sauna as a sort of "courage test" or proof of having returned to normal life after a cardiac event. From the physician's standpoint this is emotionally understandable but can become clinically problematic if it leads to overly rapid escalation of heat exposure. This tension between the need to regain agency and the necessity for caution illustrates how strongly sauna use may be charged with meanings that extend beyond physiology alone.

The safety of sauna bathing depends on several basic conditions. Strict adherence to absolute contraindications is crucial [1,2,8,31]. These include unstable heart disease, recent myocardial infarction, severe aortic stenosis, advanced heart failure, unstable arrhythmias and acute febrile infections. In the case of relative contraindications – such as uncontrolled hypertension, some supraventricular arrhythmias, high-risk pregnancy or severe disturbances of water–electrolyte balance – an individualized assessment of risks and benefits is required.

Education of users is equally important. Most adverse events in saunas – syncopal episodes, presyncope, falls with injury – stem less from heat stress itself than from a combination of overheating, dehydration and abrupt postural changes [1,2,8,9,23]. Simple advice to sit for a few minutes after completing a session, to cool the body gradually with cool rather than ice-cold water and to avoid sudden standing can substantially reduce the risk of complications. In high-risk groups such as older adults, patients taking antihypertensives, individuals with cardiomyopathies or rhythm disturbances, a detailed discussion with a physician is needed regarding target exposure time, optimal temperature and frequency of sessions.

12. Practical recommendations for users, clinicians and coaches

Although current data do not allow for a single universal "prescription" for sauna use, several principles can be proposed which are common-sense and consistent with known physiology of heat stress.

First, heat exposure should be introduced gradually [1,2,4,22,24]. Beginners should choose lower benches, limit single entries to several up to a dozen minutes, and allow at least a few minutes for cooling and hydration between sessions. Only after tolerance of such sessions has been assessed should extension of exposure time or increases in temperature be considered. Experience shows that it is precisely this phase of "slow familiarization" with sauna that is most often skipped – by younger and older users alike. People tend to copy habits of more seasoned sauna-goers without accounting for their own cardiovascular limitations or very different disease backgrounds. From a health education perspective, this is a seemingly minor but in practice crucial point at which a brief explanation of how to titrate the heat stimulus can prevent many avoidable incidents. It is worth noting that users often underestimate how strongly their

previous day's nutrition, hydration and sleep influence heat tolerance. In practice, small day-to-day variations can completely change the experience of the same sauna protocol, even when objective conditions remain unchanged. Acknowledging this variability during patient education helps prevent unnecessary alarm when a familiar session suddenly feels more taxing. Second, sauna should not be treated as a way to "compensate" for a lack of physical activity or neglect of nutritional habits [3,4,28,30,31]. Heat exposure may amplify positive lifestyle effects but cannot replace regular training, weight reduction or pharmacological treatment. In communication with patients it is worth stating clearly that sauna is an adjunct, not the foundation of prevention.

Third, when planning post-exercise recovery, sauna should be embedded in a broader scheme incorporating cooling, stretching, hydration and carbohydrate intake [11,18,19,21,22,24,27,29]. In practice, this means scheduling a sauna session for tens of minutes after the end of intense exercise rather than entering the cabin immediately while still in training gear. For some athletes, it may be more beneficial to reserve sauna use for days with lower training volume, thereby limiting the risk of stressor accumulation.

Fourth, clinicians should routinely include questions about sauna use in their history-taking, particularly in patients with cardiovascular disease [3,4,8,31]. Knowledge that a patient plans regular sauna sessions may be important when adjusting doses of antihypertensive or diuretic drugs and may sometimes prompt modifications of therapy or the proposal of less demanding protocols (lower temperature, shorter entries, presence of a companion).

An additional point concerns the often-overlooked role of environmental conditions surrounding the sauna session. The microclimate of the recovery area, availability of hydration sources, and the presence of staff trained in basic safety procedures can meaningfully influence both user comfort and clinical safety. Facilities that allow users to cool down gradually, rather than forcing abrupt transitions between extreme temperatures, tend to report fewer adverse events [1,2,8,9,23]. From the standpoint of behavioural adherence, an environment that supports quiet, unhurried transitions between stages of the session fosters a more sustainable routine, particularly in individuals who experience anxiety related to bodily sensations.

For athletes and physically active individuals, coordination between coaching staff and medical personnel is advisable when sauna is incorporated into systematic training cycles [18,21,22,24,27,28,29]. Reports from high-performance centres indicate that miscommunication between departments—particularly concerning hydration strategies, evening training schedules and sleep monitoring—can undermine potential benefits. A simple

shared protocol that specifies timing, temperature range, number of entries and recovery transitions is often sufficient to avoid these inconsistencies.

In clinical settings, discussions about sauna should be documented in the patient's record in the same manner as conversations about physical activity or dietary recommendations. This practice not only enhances continuity of care but also signals to patients that sauna use is a legitimate component of their health management plan rather than an optional "wellness add-on". Such framing can improve adherence and reduce the likelihood of unsupervised, high-risk experimentation. As understanding of the cardiovascular and autonomic effects of heat exposure expands, systematic incorporation of sauna guidance into education programmes may emerge as a valuable addition to preventive and rehabilitative strategies.

13. Limitations of available studies and gaps in knowledge

Despite the visible growth in the sauna literature, studies on cardiovascular, autonomic and recovery-related outcomes still share a number of recurring methodological weaknesses [3,4,6,7,10,11,18,21]. Many studies are observational in design, making it difficult to disentangle the impact of sauna itself from accompanying health behaviours. Individuals who use sauna regularly are more likely to exercise, less likely to smoke and more attentive to diet. Even with advanced statistical analyses, complete "purification" of the effect is impossible.

In some studies, detailed parameters such as bench height, actual time spent in the cabin or method of cooling remain implicit background factors, although in practice they may significantly modulate cardiovascular responses [2,3,4,9,22,23]. Randomized interventional trials typically involve small samples, and protocols differ considerably with respect to temperature, humidity, session duration, number of cycles and frequency of exposure [10,11,12,18,19,21]. This hampers comparisons and the formulation of universal recommendations. Analysis of available studies shows that the seemingly simple question "Do you use sauna regularly?" is often defined very differently – from two sessions per week to daily exposure, frequently in poorly described conditions. Another challenge is limited follow-up duration, which rarely allows assessment of effects on hard endpoints such as cardiovascular events or all-cause mortality.

Population heterogeneity further complicates interpretation. Findings in healthy middle-aged adults cannot be readily extrapolated to patients after myocardial infarction, and results from elite athletes may not reflect the situation of sedentary individuals. Yet in popular discourse, conclusions derived from one context are often transferred uncritically to another, fostering simplifications and myths.

In the field of post-exercise recovery, a major difficulty lies in distinguishing physiological from psychological effects [18,19,20,21,27,29]. Subjective feelings of “renewal” after sauna are undoubtedly important for athlete well-being, but they do not always correspond to measurable improvements in performance or biochemical markers. This calls for multidimensional assessment tools that combine subjective indicators, physiological markers and specific measures of exercise performance in subsequent training sessions or competitions. Specific high-risk groups, such as individuals with hypertrophic cardiomyopathy, patients with significant conduction abnormalities, frail older adults or pregnant women, are still only rarely included in sauna studies [1,2,8,31]. The absence of data in these populations does not automatically equate to contraindication but should inspire caution when extrapolating findings from younger and healthier cohorts.

14. Directions for future research

Against this backdrop, several lines of future work appear particularly promising. First, well-designed randomized interventional trials involving individuals at high cardiovascular risk, with clearly described, reproducible sauna protocols and sufficiently long follow-up to evaluate effects on hard clinical endpoints or at least on reliable surrogate markers of risk [3,4,6,7,8,10,11,18,31].

Second, multidisciplinary studies combining perspectives from exercise physiology, cardiology, sports medicine and psychology, aimed at disentangling to what extent the observed benefits of sauna use stem from changes in haemodynamic and autonomic parameters and to what extent from improved mood, better sleep quality and enhanced sense of agency in health-related behaviours [18,19,20,21,27,28,29].

Third, investigations focused on the optimal integration of sauna with other recovery and preventive strategies, such as high-intensity interval training, contrast baths, cryotherapy and educational programmes on sleep hygiene [11,17,18,21,22,24,28,29]. From a clinical and sports practice standpoint, models of “intervention packages” would be especially interesting, in which sauna forms an integral component of a comprehensive programme rather than an isolated technique.

15. Conclusions

The acute cardiovascular response to sauna — peripheral vasodilation, a rise in heart rate and short-lived hypovolaemia — resembles the load imposed by mild physical exertion, provided that sessions are brief and hydration is adequate [1,2,3,4,23].

In long-term studies, regular sauna use has been associated with a more favourable

cardiovascular profile, lower blood pressure values and improvements in selected indices of autonomic regulation [3,4,6,7,8,10,12,25,27]. In sport, sauna may be a valuable adjunct to traditional recovery methods, supporting muscle relaxation, enhancing subjective well-being and helping synchronize the activity–rest rhythm. The precondition is reasonable dosing of the thermal stimulus, integration of sessions with proper hydration and nutrition, and conscious attention to contraindications.

At the same time, sauna is not a neutral intervention. In individuals with significant cardiovascular disease, unstable blood pressure or rhythm disturbances it may become a serious burden if used without prior medical consultation. Users should be informed both about potential benefits and about risks related to overheating, dehydration and abrupt postural changes. In light of current evidence, sauna can be regarded as a useful component of a healthy lifestyle and of structured recovery programmes, but not as a stand-alone remedy that replaces regular physical activity, rational diet or pharmacotherapy. Carefully designed interventional studies are still required to refine sauna protocols for different populations, to clarify how heat stress interacts with cardiovascular and autonomic regulation during recovery, and to translate these insights into practical guidance for clinicians, coaches and athletes [3,4,6,7,10,11,18,31].

DISCLOSURE

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AUTHOR CONTRIBUTIONS

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Methodology: M.K., K.K.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

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