Effects of sauna on cardiovascular and lifestyle-related diseases

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ABSTRACT

Sauna bathes are popular practices of healthy young, adult and older people. Frequently, the sports medicine physicians are invited to evaluate the impact of the sauna on diseases and on health in general. Sauna can be beneficial or dangerous depending on its use. In the past few years the sauna is being considered beneficial for the cardiovascular diseases' patients, as the heart failure and lifestyle-related diseases, mainly by improving the peripheral endothelial function, through the increase of the cardiac output and peripheral vasodilation. The endothelial dysfunction is present in most of the cardiovascular diseases. The present article intends to review the sauna effects on the cardiovascular system in healthy individuals and in some cardiovascular diseases.

INTRODUCTION

Bathing in one form or other is the oldest custom people have practiced. It has been closely linked with the cultural movement, and has become an integral part of the history of civilization[(1)].

Sauna and Turkish bath are very popular in the Scandinavian and the Middle East countries respectively, and have been practiced with therapeutic purpose in many diseases for centuries.

The search for well-being and the fact that physical activities are increasingly being recommended to diminish sedentary life and incidence of diseases, bring as a consequence the proliferation of organizations and institutions related to sports practice and sauna, such as clubs and specialized clinics (spas). The target public consists of the young and the elderly, healthy or not.

With the increase of the incidence and prevalence of the cardiovascular diseases, obesity and sedentarism in the industrialized countries, including Brazil, we can observe the greater number of patients with cardiovascular diseases frequent these institutions and specifically sauna.

Sports medicine physicians are frequently asked about the possible effects of sauna on athletes' health, sedentary individuals and on the patients with different disease.

Physiological effects[(2-4)], benefits and risks[(5)], facts and fables[(6)] about the sauna were subject of extensive review. Recently, sauna was studied as a therapeutic option for cardiovascular diseases[(7)] and an improvement in clinical indicators with thermal therapy in lifestyles-related diseases was observed[(8)].

The main purpose of the present article is related to such therapeutic option, analyzing the thermoregulatory and cardiovascular variables involved with sauna exposure.

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SAUNA

Sauna is characterized by its high temperature and dry air. The basic sauna consists of a wood-paneled room, an unpainted wooden platform and a heat source (electric, with a log source or gas). The size of the sauna should also be at least three m^2 to allow proper heat balance, suitable humidity and adequate ventilation (3 to 8 times per hour). The suggested temperature is of 80º-100ºC at the face level and 30ºC at floor level[(9)]. The relative humidity should be of 10% to 20% (40 to 70 g of water vapor/kg air)[(9-10)]. The usual ritual consists of several short stays (5 to 20 min) in the sauna, alternated with cooling-off periods and followed by oral intake of fluids[(6,11)].

ACUTE SAUNA EFFECTS ON THERMOREGULATORY AND CARDIOVASCULAR VARIABLES

The sauna bath represents a heat load of 300-600 W/m^2 of body surface area[(10)]. The skin temperature rapidly increases to ± 40º-41ºC[(2,9-10)] and the thermoregulatory mechanisms are triggered.

Evaporative heat transfer by sweating is the only effective body heat loss channel in dry sauna[(10)].

The sweating begins rapidly and reaches its maximum level in ± 15 min. The total sweat secretion can go up to 0.5-1 kg/h and represents a heat loss of about 200 W/m^2 of the body surface area[(2,10)].

The body cannot compensate for the heat load and causing elevation of internal temperature. The rectal temperature increase depends on the condition of the heat exposure and ranges from 0,4ºC[(12)] to 1ºC[(13)]. The skin circulation increases substantially in order to prevent the body from heating. The skin blood flow, in the thermo-neutral condition (± 20ºC) and in rest corresponding to ± 5-10% of the cardiac output, can reach ± 50-70% of the cardiac output (7-8 L/min) in the sauna[(14)]. The arterial blood pressure tends to decrease. However, such reduction is prevented by the elevation of the cardiac output by increased heart rate[(3,14)] and by the reduction of the blood flow to internal organs[(14-15)]. The cardiac stroke volume does not change[(3,14)]. The effect of sauna baths on the arterial blood pressure is variable (table 1). Repeated sauna baths improve the heat tolerance and reduce the magnitude of the changes of the variables mentioned above[(12)].

The thermoregulatory and cardiovascular effects of sauna exposure are resumed in table 1.

SKIN VASODILATION IN RESPONSE TO THERMAL STRESS IN HEALTHY INDIVIDUALS

Reflex control of blood flow to nonglabrous skin in humans is accomplished by two branches of the autonomous sympathetic nervous system: a noradrenergic active vasoconstrictor system[(26)] and an active vasodilator system acetylcholine-dependent[(27)] mediated by nitric oxide (NO)[(28-30)] and prostaglandins[(30)].

The nitric oxide is an important mediator of the homeostasis process and the defense mechanisms of the body. In vascular bed,

TABLE 1
Acute physiological effects of sauna bathing

Effect	Result	References
Skin temperature	↑ up to 40ºC within a few min	2, 9
Rectal temperature	↑ by 0.4ºC (92ºC for 20 min) ↑ by 1ºC (80ºC for 30 min)	12 13
Oral temperature	↑ from 1ºC to 3ºC	16, 19, 80, 90
Sweating	↑ sweat rate from 0,6 to 1 kg/h (80ºC-90ºC)	2, 10
Total peripheral resistance	↓ ± 40%	14, 89
Skin blood flow	↑ from 5%-10% to 50%-70% of cardiac output (from about 0,5 to 7 L/min)	14, 39
Blood flow to internal organs	renal ↓ ± 0.4 L/min splanchnic ↓ ± 0.6 L/min	14, 39
Blood flow to muscles	↓ ± 0.2 L/min	14, 39
Heart rate	Up to 100 bpm during moderate sauna bathing in accustomed subjects Up to 150 bpm during intense sauna bathing or in unaccustomed subjects	2, 17, 18, 19, 24, 82 16, 19, 20, 21, 25, 58, 80, 90, 93
Cardiac output	↑ from 5-6 L/min up to 9-10 L/min	3, 14
Double product	↑ from 1.5 to 3 times	14, 16
Cardiac stroke volume	unchanged	3, 14
Systolic blood pressure	unchanged or ↓ by 8 to 31 mm Hg or ↑ by 9 to 21 mm Hg or ↑ and ↓ during sauna bathing	12, 16, 18, 19, 80, 90, 93 17, 20, 22, 82 16, 19, 21, 23, 25, 58
Diastolic blood pressure	unchanged or ↓ by 6 to 39 mm Hg	16, 17, 93 12, 18, 19, 20, 21, 22, 23, 25, 80, 82, 90

↑ = increased; ↓ = decreased.
Adapted and complemented from ref. 5.

the NO is produced by the endothelial cells through the endothelial nitric oxide synthase enzyme (eNOS), that is activated by mechanical stress (as shear stress, or tangential force done by the blood flow on the endothelial surface)[31-32] and stimulation by bradykinin and acetylcholine. The nitric oxide has many functions, but its action as endothelium derived relaxation factor is the most important in order to maintain the vascular homeostasis. It is widely accepted that nitric oxide produced by endothelial cells effects vasodilation in normal, healthy human vessels, including those found in the skin[28,33-37]. The activation of the vasodilator system is responsible for 80% to 95% of the increase of the skin blood flow during the thermal stress[38-39]. Considering that the total skin blood flow can reach 7-8 L/min in sauna[14], or 70% of the cardiac output during thermal stress, it is obvious the critical role of the active vasodilator system in the thermoregulation response and in the systemic hemodynamics variables.

SAUNA AND CONGESTIVE HEART FAILURE (CHF)

Endothelial function in CHF patients

In patients with CHF, the peripheral vascular resistance is increased via activation of the neurohormonal system, namely by autonomous sympathetic nervous system, rennin -angiotensin- aldosterone system (RAAS), and endothelin system[40-43].

The vascular endothelial function in patients with CHF, mainly represented by the endothelium-dependent vasodilation, is altered[44-50]. Such alteration leads to the vascular tonus increase and remodeling of the blood vessels, which reduces the peripheral blood flow. Hence, the amount of oxygen for the skeletal muscles is compromised, with subsequent clinical symptoms and progressive exercise intolerance. The vascular endothelial dysfunction in the CHF is mainly due to the decrease of the nitric oxide production induced by the reduced gene expression of eNOS[51-53] and increased oxidative stress[54-55].

Thermal stress and endothelial function in CHF patients

The endothelium-dependent vasodilation alteration has been virtually reported in all cardiovascular diseases, including in atherosclerosis[56] and CHF. Using sauna bath as therapeutic option for CHF is not very recent, since in the 1950's decade the first studies with CHF patients were conducted[57-58] and the potential beneficial effect of sauna was suggested[58]. However, some time later the studies emphasized especially its risks and recommended caution in its use for cardiac patients[20-21,59].

It is widely known that the vasodilators, such as angiotensin converting enzyme inhibitors, improve the CHF and increase the peripheral perfusion[60]. Since the endothelial function is altered in CHF, the endothelium is considered as a new therapeutic target in heart failure[61]. Hence, the angiotensin converting enzyme inhibitors[62-63] and physical training[64-65] improve the endothelial function in CHF patients. One of the proposed mechanisms for the alteration of the endothelium-dependent vasodilation would be through the decrease of the NO production in the peripheral vessels in CHF patients[51-53]. The decrease of peripheral perfusion would decrease the shear stress[66]. The shear stress is an important stimulus for NO production[67] and eNOS expression[32,68-70]. On the other hand, the heat increases the cardiac output and improves the peripheral perfusion in CHF patients[18]. Consequently, with the cardiac output improvement in CHF patients, an increase of the shear stress, NO production and eNOS expression are expected. In other words, an improvement in the endothelial function in the peripheral vessels and consequently in the cardiac function is observed. Probably, the thermal stimulation directly increases the eNOS expression, since in a recent study, it was shown that heat increases the arterial eNOS expression[71].

It was recently reported that the thermal therapy in 60ºC produced systemic arterial, pulmonary arterial and venous vasodilation, reduced the preload and afterload and improved the cardiac output and the peripheral perfusion[18], clinical symptoms[72-73], life quality[73], and cardiac arrhythmias in CHF patients[74].

In infants with severe CHF secondary to ventricular septal defect, the sauna therapy decreased the systemic vascular resistance and increased the cardiac output[75]. The sauna benefits in CHF patients are possibly caused by the improvement of the vascular endothelial function and normalization of the neurohormonal system[76].

Ikeda *et al.*[77] in an experimental study with hamsters, discovered that the observed improvements in the sauna therapy are due to the eNOS expression increase in the arterial endothelium. Later, in another study[78], they showed that the thermal therapy with sauna improves the survival of the TO-2 cardiomyopathic hamsters with CHF and, more recently, showed that the repetitive therapy with sauna increases the eNOS expression and the nitric oxide production in artery endothelium of TO-2 cardiomyopathic hamsters with CHF[79].

SAUNA AND SYSTEMIC ARTERIAL HYPERTENSION

Davies[22] evaluated the pressure response in three hypertensive individuals during sauna exposure (85ºC, 15 min) and immediate exposure to 24ºC e 4ºC (cold phase) and observed the reduction of the blood pressure in one patient (154/80 mm Hg for 110/60 mm Hg) in the sauna and increase of blood pressure in the cold phase of the experiment. The two other hypertensive patients showed an increase of the blood pressure during sauna (non-significant) and in the cold phase (up to 252/147 mm Hg). In the author's opinion, the blood pressure does not increase significantly in sauna; it even decreases. Caution should be taken in the exposure to 4ºC.

Sohar *et al.*[21] did not find reduction in the systolic (SBP) and diastolic blood pressure (DBP) in 6 hypertensive patients during sauna and in 2/6 patients the SBP and the DBP importantly increased. According to the authors, the hypertensive individuals should seriously consider the sauna risks. Luurila *et al.*[80] did not find change in the SBP during sauna, but a decrease of the DBP in 11 young patients with essential arterial hypertension after 4 weeks of treatment with placebo, and single exposure to sauna in the end of the experiment was observed (85ºC and 14-20 min).

The repetitive exposure to sauna (80ºC, 1 h, 2x/day, 7 days) in healthy individuals did not change the systolic blood pressure, however, a reduction of the diastolic blood pressure was observed[12].

Recently, the effect of repeated thermal therapy was evaluated[8,81] (60ºC, 15 min sauna, 30 min with blanket in the supine position post-sauna, 1x/day, 2 weeks) in 25 men with at least one coronary risk factor (8 with arterial hypertension, 3 with mellitus diabetes, 8 with hypercholesterolemia and 15 smokers). It has been observed that 2 weeks of sauna exposure significantly reduced the systolic and diastolic blood pressures. (SBP: 128 ± 18 mm Hg for 124 ± 17 mm Hg, p < 0,01; DBP: 77 ± 17 mm Hg for 72 ± 16 mm Hg, p <0,05). Winterfeld *et al.*[82-83] reported the beneficial effect of sauna, regularly practiced in hypertensive patients. In a study with 180 hypertensive patients and with other cardiovascular diseases, the mean blood pressure was lowered from 162/110 mm Hg to 139/92 mm Hg[82]. In another study[83] with 47 hypertensive individuals (sauna 2x/week, during 3 months) the blood pressure decreases from 166/110 mm Hg to 143/92 mm Hg.

SAUNA AND CORONARY HEART DISEASE

The endothelial dysfunction is a systemic disorder involved in the etiopathogenic of atherosclerosis and its complications[46,84]. The endothelial function is altered in patients with lifestyle-related diseases, such as hypercholesterolemia, systemic arterial hypertension, diabetes mellitus, smoking and obesity[85].

The endothelial cells secrete various vasoactive substances such as nitric oxide, prostacyclin, endothelium derived hyperpolarizating factors, endothelin, thromboxane, growth factor, cytokines among others, and the endothelial function is determined by the balance of these substances[86]. It is believed that the NO decrease and the increase of the NO degradation induce atherosclerosis and probably cardiovascular diseases[56,85,87].

Many studies have shown that sauna exposure is well tolerated in patients with stable coronary arterial disease (CAD)[16-17,82,88].

However, ventricular ectopic beats[16,18,20-21] and electrocardiographic alterations suggestive of ischemia were reported[16,20] and the recommendation about sauna use in patients with CAD is contradictory[20-21,23,89]. Two Finnish studies[16,88] report that sauna was practiced after myocardial infarction or cardiac surgery. In a study with 117 patients after myocardial infarction, 87% practiced regular sauna bath immediately after hospital discharge[16]. During 10 years follow-up, 82% of the patients continued to regularly practice sauna baths[88].

The angina pectoris incidence during daily physical activity was of 60%. Cardiac arrhythmias and electrocardiographic alterations suggestive of ischemia were significantly smaller during sauna comparing to an ergometric test[16].

Recently, Giannetti *et al.*[17] showed that sauna in patients with stable CAD is clinically well tolerated, although it is associated with reversible ischaemic alteration in the myocardial scintilography. Imamura *et al.*[81] reported that the repetitive treatment with sauna improved the endothelial function, altered in patients with coronary artery disease risk factors. Biro *et al.*[8] evaluated the effect of the repetitive treatment with sauna on lifestyle-related diseases and showed that the repeated thermal therapy improved the endothelial function and decreased body weight. As described above, the endothelial dysfunction presents the first step of the atherosclerosis and the authors suggest that the sauna treatment could prevent the atherosclerosis, especially if combined with diet and exercise.

RISK OF SAUNA IN HEART DISEASE PATIENTS

The clear contra-indication of sauna are: infections diseases, acute thoracic pain, unstable angina pectoris, recent myocardial infarction (4-6 week) descompensated heart failure, severe aortic stenosis, important cardiac arrhythmias, uncontrolled hypertension[16,88-89].

The effects of the use of β-blockers in sauna in healthy individuals[90-91] show that the blood pressure decreases significantly in the treated group, comparing to placebo, however, no important hypotension clinically was observed. Nevertheless, hypotensive reactions were reported in sauna with hypertensive patients treated with β -blocker[80].

In healthy individuals with transdermal nitroglycerin patches[92], an increased absorption of nitroglycerin in sauna and a significant decrease of the diastolic blood pressure were observed. The combination use of a short term nitroglycerin patch and sauna could importantly reduce the diastolic blood pressure and cause symptoms of cardiac ischemia. The stable CHF patients (ischemic and non-ischemic dilated cardiomyopathy) under maintenance treatment with the angiotensin converting enzyme inhibitors, diuretics, β-blockers and digital tolerate well sauna[16,18,72,76].

Hypertensive patients under treatment with calcium channel blockers[80], and non-hypertensive individuals treated with guanethidine[90] or captopril[91] tolerate well sauna. Sauna combined with alcohol intake increases the hypotension risk in healthy individuals[93], although it does not seem to cause cardiac arrhythmias.

ACCLIMATIZATION AND SAUNA

The studies about sauna originate mainly from countries with moderate and cold climate, and are conducted with individuals supposedly little adapted to heat. The sauna effect on acclimatized patients to tropical climate is questioned. The first step towards this answer was taken in our laboratory when the method of sauna thermal stimulus was standardized. Our results (submitted to publication) showed that the physiological responses of individuals living in tropical regions were similar to that ones found in the literature.

In resume, the systemic effects of sauna seem to occur via increase of the cardiac output and peripheral vasodilation, increase of the shear stress and improvement in the nitric oxide production via increase of eNOS expression. Such fact results in the improvement of the endothelial function, the common denominator found in virtually all cardiovascular diseases.

CONCLUSION

Sauna can be regarded as therapeutic option in patients with systemic arterial hypertension or cardiac failure and as prevention method against diseases related to endothelial dysfunction.

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