Effects of sauna bath on the cardiovascular system

Wpływ kąpieli w saunie na układ sercowo-naczyniowy

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Abstract
Sauna is a form of biomedical regeneration consisting of consecutive exposure to two opposite thermal agents. Firstly, during sauna bath, a person is exposed to high temperature (ranging from 70 to100 °C) at low relative humidity. Secondly, thermal exposure is followed by body cooling. One sauna bath consists of two or three repeated cycles of heat exposure followed by cooling off. Sauna can be applied in sport, recreation and therapy. The aim of this publication is to present cardiovascular changes elicited by the sauna bath. High temperature induces cutaneous vasodilation and, consequently, an incerase in cutaneous blood flow. Myocardial contractility and heart rate increase. These changes lead to alterations of blood pressure and cardiac output. Abnormalities of the electrocardiogram pattern, changes in activity of renin-angiotensin-aldosterone and blood rheological properties are observed. Cardiovascular responses to sauna bath depend both on the mode and intensity of warming and the applied methods of cooling. The risk of the sauna bath-related cardiovascular complications in healthy persons is small. Nevertheless, it is higher in individuals, who apply excessive heat exposure in order to reduce the body mass or combine sauna bathing with physical effort or alcohol consumption. However, sauna bathing in patients with cardiovascular disease should be used cautiously and preceded by individual assessment of potential risks, considering concomitant medication and the methods of both heat exposure and, especially, cooling off.

Słowa kluczowe
sauna, układ sercowo-naczyniowy, serce, ciśnienie tętnicze, EKG

Streszczenie
Sauna jest zabiegiem ciepłoleczniczym, który wykorzystuje kontrastowość bodźca termicznego. Kąpiel w saunie odbywa się w pomieszczeniu o temperaturze 70-100 ºC i niskiej wilgotności względnej powietrza**.** Po ekspozycji ciepła następuje ochładzanie ciała. W czasie jednego pełnego zabiegu, naprzemienne przegrzewanie i ochładzanie, powtarzane jest dwa lub trzy razy. Sauna znajduje zastosowanie w sporcie, rekreacji i terapii. Celem pracy jest opisanie zmian zachodzących w układzie sercowo-naczyniowym. W wysokiej temperaturze otoczenia dochodzi do rozszerzenia skórnych naczyń krwionośnych i wzrostu skórnego przepływu krwi. Zwiększa się kurczliwość mięśnia sercowego, a częstotliwość pracy serca ulega przyspieszeniu. Pobyt w saunie wpływa na zmiany ciśnienia tętniczego krwi i pojemności minutowej serca. Stwierdzono także zmiany w zapisie EKG, aktywności układu renina-angiotensyna-aldosteron oraz właściwości reologicznych krwi. Reakcje zachodzące w układzie sercowo-naczyniowym uwarunkowane są zarówno intensywnością ogrzewania jak i sposobem ochładzania ciała. Ryzyko wystąpienia komplikacji sercowo-naczyniowych pod wpływem sauny u osób zdrowych jest niewielkie, wyższe jednak u osób stosujących nadmierną ekspozycje np. celem redukcji masy ciała lub łączących korzystanie z sauny z wysiłkiem lub spożywaniem alkoholu. Korzystanie z sauny przez osoby z chorobami układu krążenia powinno być poprzedzone indywidualną oceną ryzyka z uwzględnieniem stosowanego równocześnie leczenia oraz sposobu aplikacji ciepła i ochładzania organizmu.

INTRODUCTION

Traditional Finnish sauna, known for over 2 thousand years, is currently used worldwide because of its multifactorial effects on the human organism. Thermal therapy procedures in sauna constitute one of the so-called biomedical regeneration (health spa) and are used as leisure activities, in sport, as well as in therapy[1-11].

Finnish sauna is a combination of overheating the body with hot, dry air with subsequent body cooling by application of procedures involving treatment with cold water[12].

Overheating in sauna occurs in a sauna room at temperature of 70 to 100 degrees Centigrade (sometimes up to 120°C) at low relative air humidity, ranging 10-20% (40-70 g of

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water steam / 1 kg of dry air)[13,14]. Pouring of water (approximately 0.5 l) onto heated stones placed on the stove heating the interiors of sauna induces formation of steam and a rapid increase in air humidity, even to 50%[12,13,15-17]. Duration of a stay in the heated sauna cabin is usually 5 to 15 minutes. Following each overheating, body cooling takes place, e.g. with cold shower or immersion of the whole body in cold water. During single complete sauna bath, alternating overheating and cooling of the body is usually repeated two or three times and the whole procedure is finished by a rest, during which consumption of fluids (water, fruit juices) is indicated in order to replace fluids[18,19].

A once-per-week frequency of sauna heat therapy is recommended. Intensity of the effects of sauna on the organism is increased by raising temperature, air humidity, and duration of stay in the sauna cabin[12] as well as by cooling conditions – method and temperature used during cooling off, e.g. total body bath, shower at moderate temperature or solely a rest[20].

Conditions of sauna bath use depend on the effectiveness of individual theramoregulatory reactions, age, sex, cardiovascular and respiratory system functioning[1,2,20], individual preferences of sauna users, as well as on traditions associated with sauna use in a particular country. For example, in Germany, high temperature (90-100ºC) and low air humidity (10-15%) are most frequently applied; in Turkey – the opposite (70-80º, 40%)[15,21].

A so-called steam sauna is another type of sauna bath, where air temperature is 45-50ºC and relative humidity – 100%. Currently, especially in a clinical setting, infrared sauna is used. It is a non-steam, low air temperature (40-65ºC) sauna, where ceramic infrared radiators are used instead of traditional stoves[1,2,4].

Finnish sauna is most popular and most frequently used and its effects on human organism have been subjected to numerous research studies.

Finnish sauna bath variably affects human organism. As a result of heat exchange with the environment, body temperature increases[12]. Sauna exerts its effects on the adrenergic system, endocrine glands, especially the adrenal glands stimulated both by the hypothalamic-hypophyseal-adrenal axis and the renin-angiotensin-aldosterone system[15,22]. It affects the respiratory system, where vital capacity (VC), tidal volume (TV), minute ventilation and 1-sec forced expiratory volume increase[12,23]. Sauna bath influences the locomotor system by improving elasticity of the fibrous tissue of articular capsules and reducing skeletal muscle tone[12,16]. This paper pertains to changes in the cardiovascular system.

Description of adaptation of the cardiovascular system to conditions of sauna bath (i.e. overheating) and subsequent cooling off is very important, because, apart from healthy and young persons, also elderly people, often suffering from various diseases or being at higher risk of occurrence of cardiovascular diseases, use sauna[1,2]. In the following sections, we will separately describe the effects of heating on the cardiovascular system and neuro-humoral mechanisms, and – subsequently – the effect of cooling, rheological effect of sauna bath and potential undesirable effects on the cardiovascular system.

EFFECTS OF HEATING

Changes in body temperature and skin, visceral, renal and muscular blood flow

During sauna bath, the organism absorbs more warmth from the environment than it is capable to return. Both mean skin temperature and body temperature increase up to 37.6-40ºC[15,16,24-27]. Temperature at tips of the nose and ears is even higher, which can induce pain in these body regions. Duration of bath, room temperature and humidity and the effectiveness of thermoregulatory mechanisms determine the changes of body temperature[20].

Increase in skin temperature induces vasodilation of skin arterioles and an increase in blood flow through skin vessels[28]. In a thermoneutral temperature (approximately 20ºC), skin blood flow constitutes 5-10% of resting cardiac output, whereas it can increase as high as to 50-70% of cardiac output during heating in the sauna. Increase in body temperature by 1ºC is accompanied by a two-three fold increase in skin blood flow as compared to resting conditions. The above changes occur within several minutes of organism exposure to the high temperature of sauna[29].

Temperature changes modify cutaneous vasomotor function by acting on skin receptors, thermoregulatory centre in the hypothalamus and the sympathetic system. Cutaneous arterio-venous anastomoses are rich in α receptors that induce noradrenalin-mediated vasoconstriction[20]. At high ambient temperature, as a result of inhibition of the tonic activity of sympathetic fibres, cutaneous vasodilation occurs, especially of the vessels of distal parts of the extremities (fingers, palms).

In proximal parts of the limbs and in the skin of the trunk, heat-induced vasodilation depends primarily on an in creased activity of cholinergic sympathetic sudomotor fibres that are responsible for sweating. The greatest number of sweat glands (approx. 2000/cm^3) is located in the skin of the thorax and the limbs. Sweat contains a kinase – kallikrein that converts kininogen to bradykinin – a nonapeptide inducing cutaneous vasodilation via the β2 receptor and nitric oxide (NO)[20,30]. As a result of this mechanism, blood flow can increase by as much as 30-50%[20,31]. Direct stimulation of the cholinergic fibres is likely to also contribute to cutaneous vasodilation induced by heat[20].

Stimulation of sweat glands activity and increased sweat secretion that – by evaporation – takes away excessive warmth constitutes the principle defence reaction of the organism to overheating. Volume of sweat during sauna bath ranges from

0.6 to 1.0 kg/hour[32]. A loss of an average of 270 mmol of sodium, 35 mmol of potassium and 210 mmol of chloride accompanies sweating. Sauna bath, however, causes small changes in plasma electrolyte concentrations and does not affect electrolyte concentrations in the urine[19].

Skin temperature begins to fall with initiation of the process of sweating. Nonetheless, in spite of intensive sweating, an increase in rectal temperature is observed during sauna bath. In adults, an increase in rectal temperature by 0.9°C was observed after 30-minute sauna bath at air temperature of 80°C. Rectal temperature rises by 1°C in children as fast as after 5 minutes of sauna bath at air temperature of 70°C. Temperature increase is faster in children, which results from the greater body mass to height ratio. Rectal temperature returns to baseline value after approximately 15 minutes following exposure to heat[14].

After 15 minutes of infrared sauna bath, an increase in brachial artery blood flow by 68% was observed; the significant increase was maintained for 30 minutes after termination of heat exposure[2]. According to Vuori[29], a small reduction in muscular blood flow (0.2 l/min.) occurs as the effect of high temperature on the whole organism. Thermoregulatory skin vasodilation occurring during use of sauna is accompanied by a compensatory reduction in blood flow through the visceral vascular bed (a reduction of approximately 0.6 l/min.) and the kidneys (a reduction of approximately 0.4 l/min.)[20,29].

Changes in heart rate, cardiac contractility and cardiac output

During sauna bath, heart rate acceleration is observed. In young persons regularly using sauna, heart rate (HR) increases to approximately 100-110 beats/minute. With the rise in ambient temperature, HR increase as much as above 140-150 beats/minute[4,16,24,26,33-36]. In persons who do not use sauna baths on a regular basis, heart rate can increase even more, which is attributed to the lack of adaptation of the organism to high temperature[34]. A heart rate increase to approximately 120 beats/minute constitutes a beneficial adaptation reaction, while an increase to above 140 beats/minute can be unfavourable, as it is associated with a rise in cardiac work accompanied by shortening of the diastole. Increase in blood temperature and reflex stimulation of adrenergic cardiac beta-receptors is the likely mechanism of heart rate increase[24]. The rise in HR depends on factors including duration of stay in the sauna, age, gender and the degree of physical endurance of the organism. High humidity in sauna cabin has a small effect on heart rate[24]. After leaving the sauna room, heart rate decreases. During prolonged and gradual body cooling (e.g. during a shower), HR decreases slowly. If cooling occurs at room temperature, heart rate returns to baseline values after approximately 1-4 hours[24] following sauna exposure.

Experimental studies suggest that warmth induces an increase in cardiac contractility[22]. However, according to the majority of researchers, regular use of sauna does not cause statistically significant changes in stroke volume (SV)[15,1725,29,37].

The effects of sauna bath on cardiac output (CO) raise highest controversies. According to many authors, CO rises proportionally to heart rate increase[17,21,38,39]. Eisalo[37] found, based on studies conducted in healthy volunteers, that during sauna bath, CO increases by approximately 75% (up to 10 l/min.). Other authors demonstrated a two-fold increase in cardiac output when body temperature increased to 39-39.5°C[31]. However, Kiss *et al.*[40], who assessed cardiac output using the Fick method, did not confirm these results. The increase in CO, mainly due to HR acceleration, was 0.47 l/min. and was insignificant, while SV was even somewhat reduced. The above studies involved persons subjected to a single sauna bath, therefore, evaluation of cardiac output in regular sauna users cannot be performed based on these studies.

Changes in CO occurring as a result of heating in the sauna, on one hand, reflect peripheral vasodilatation, a fall in blood pressure and a reduction in venous return and compensatory changes in the renal and splanchnic circulations, on the other hand – a rise in HR and changes in cardiac contractility[16,20,24,29,31,33].

Changes in peripheral vascular resistance and arterial pressure

In the process of adaptation of the cardiovascular system to conditions of sauna, increase in HR and reduction of peripheral resistance are most important[18]. The majority of authors demonstrated that a reduction of peripheral vascular resistance occurs during sauna bath[1,17,24,29,38,41]. Eisalo[37] found that this reduction during sauna bath is 42%.

Effects of sauna on blood pressure (BP) are variably described in research papers and its assessment depends on the measurement method, sauna type, duration of exposure, eliciting the "evaporation effect" and adaptation of sauna users to high temperature. Studies, where sphygmomanometer was used, yielded various results: slight increase[36,42], no changes[33,38,43,44], decrease in systolic blood pressure[1,6,40,45], as well as a decrease of diastolic blood pressure of various degree[1,2,4,7,16,24,33,34,46].

In Finnish sauna, where there is low humidity (5-10%), haemodynamic changes, such as a fall in BP and vascular resistance, are greater[47].

Enhanced air humidity obtained by water pouring onto the heated stones induces a transient, small (3-15 mmHg) rise in systolic blood pressure[24]. Imamura and Kihara showed mild but statistically significant reduction in BP in patients subjected to regular infrared sauna baths for two weeks[1,2]. Maintenance of BP within a constant range may constitute a problem if sauna users are in a sitting position, where temperature-induced peripheral vasodilation in the lower extremities and the lack of muscle pump activity compromise the reflex compensatory vasoconstriction and reduce venous return[20,29].

If exposure of the organism to high temperature is prolonged and the user additionally assumes standing position in the sauna, BP can fall to values inducing syncope. The risk of large blood pressure fall is highest in the elderly with disturbances in blood pressure control and in patients with hypertension receiving antihypertensive drugs[37,38]. Persons with low BP or with orthostatic disturbances may experience headache, dizziness and general weakness during sauna bath[33].

Haemodynamic changes resulting from sauna are similar in patients with hypertension and in healthy persons[15,17,37,48-50].

Winterfeld *et al.*[48-50] evaluated the effects of regular sauna baths on BP and observed that using sauna twice a week for three months in 46 patients with hypertension resulted in BP decrease from a mean of 166/101 to 143/92 mmHg[50]. In another similar study in 180 patients, blood pressure decreased from 162/110 to 139/92 mmHg[48].

Changes in cardiac workload

Determination of the product of systolic blood pressure and heart rate, called double product (DP) is one of assessment methods of myocardial oxygen demand. During sauna bath, it markedly increases (1.5 – 3 fold). In regular sauna bathers, metabolic cardiac workload is small in contrast to those, who use sauna sporadically[29]. Lack of habituation can induce marked tachycardia and increased sympathetic activation thus increasing cardiac workload. Furthermore, very high heart rate shortens ventricular filling time and leads to a decrease in SV. A fall in BP may additionally reduce perfusion pressure. The above changes can cause myocardial ischaemia in persons with pre-existing coronary artery pathology[33]. Cardiac workload is proportional to the intensity of organism overheating in the sauna. When sauna bath is of moderate intensity, it does not significantly affect oxygen delivery to the heart[29].

According to some authors, cardiac workload associated with sauna bath is similar to mild physical exercise[25]. Some authors report that cardiac workload in sauna is approximately 60 W[15], and minute oxygen consumption increases by approximately 20%[24]. Every-day physical activity involving fast walk or climbing up the stairs can load the heart to a greater extent than the warmth therapy procedure in sauna. The most important differences between haemodynamic parameters observed in sauna and those occurring in response to physical exertion pertain to changes in resistance and blood flow in different peripheral vascular beds and to pressures in the systemic circulation. Peripheral resistance is reduced during both above activities, however, blood flow is directed to the muscles during physical exercise, whereas during sauna bath – to the skin. Besides, during physical exercise, heart rate is increased and blood pressure rises. In sauna, heart rate does increase but blood pressure falls. As a consequence, even frequent sauna bathing does not induce cardiovascular adaptive changes, similar to those associated with intense physical training. Absence of an increase in afterload at unreduced or even an increased cardiac output result in a small risk of heart failure during sauna bath[29]. Imamura and Kihara[1], applying heating up to 60°C in infrared sauna, demonstrated a beneficial effect in a group of patients with chronic heart failure (NYHA II/III).

Nevertheless, there is a risk of local coronary artery hypoperfusion and even myocardial infarction, especially in persons using intense heating with subsequent rapid body cooling[51].

Electrocardiographic changes

During sauna bath, there are various changes in the electrocardiogram (ECG) in a healthy person. Early studies by Lundgren (1938), Gernandt (1944) and Otto (1947 and 1948) described flattening of the T wave in about 1/3 of the examined persons and lowering of the ST-T segment. Moreover, a rise in P amplitude and PQ prolongation as well as shortening of QRS complex and R amplitude reduction were recorded. Eggers and Goll (1952) found no changes in the ECG in 42 out of 100 healthy persons enrolled into their study. In the remaining participants, one to several of the following abnormalities were observed: increased P amplitude and lowering of the ST-T segment in lead II, flattening of the T wave in leads I to III and ectopic supraventricular beats. Sohar and Solonin confirmed occurrence of supraventricular and ventricular dysrrhythmias[26,39]. The ECG curve normalises very quickly following termination of the exposure[24].

Based on occurrence of abnormalities in ST-T segment formation and heart dysrrhythmia, some researchers concluded that tachycardia and in crease cardiac workload (DP) induced by high sauna temperature can negatively affect coronary circulation[26,52]. Studies that confirmed this statement were conducted only on persons who used sauna irregularly[26,29].

Changes in neuro-humoral factors

Increased sweating occurring during sauna bathing results in a reduction of plasma volume[53] and a loss of ions[19], which contributes to changes in renin secretion and activity of the renin-angiotensin-aldosteron system[54].

Kosunen *et al.*[42], who evaluated the effect of single sauna bath on plasma renin, angiotensin II and aldosterone levels, observed an increase in all the above components of the renin-angiotensin-aldosterone system. Highest renin and angiotensin II levels occurred by the end of 20-minute heat exposure, while the highest rise in aldosterone concentration was noted after 30-minute rest following the exposure in the sauna cabin. Lammintausta[35], who also assessed the effects of single sauna bath on plasma renin and aldosterone confirmed that concentration of the former substance mark-

edly increases dueing heat exposure and its elevated level persists for up to 1 hour following termination of the exposure, whereas aldosterone secretion was not significantly changed.

Bussien[55] assessed vasopressin concentration before entering the sauna room and 30 and 60 minutes after termination of the whole procedure that involved two heat exposures followed by cold shower and rest. He found that vasopressin level significantly increased 1 hour after termination of sauna bath. Plasma osmolarity studies and assessments of plasma renin, adrenalin, noradrenalin, cortisol, aldosterone and β-endorphine levels performed concomitantly did not show any statistically significant changes.

Other authors demonstrated that plasma noradrenalin level assessed during heat exposure shows an increase of above two-fold[4,47,53,56-60] and remains elevated for 15 minutes after termination of body cooling[56]. During exposition to sauna heating, plasma adrenalin level increases insignificantly[56,57,59,60] and returns to baseline value after the body has been cooled[56]; other studies demonstrate that adrenalin level is unchanged during sauna bath[4,47,53,60]. Unchanged adrenalin concentrations were found mainly in persons, who use sauna bathing systematically[16]. Adrenalin concentration also depends on the method of body cooling following heat exposure. Sauna bath followed by body cooling at room temperature did not affect adrenalin level, unlike body immersion in cold water that induced its marked increase[59].

The rise of blood catecholamine levels may be interpreted as a marker of the degree of caloric load of the organism (caloric stress) and of the adaptive response of the organism to this load[5]. Miyato *et al.*[6] , in turn, evaluated catecholamine levels during a four-week observation of patients with chronic heart failure, who used sauna baths at 60°C once daily for the whole study period. After termination of the series of exposures, they found a statistically significant decrease in plasma adrenalin and noradrenalin levels.

No effects of heating during sauna bath on changes in atrial natriuretic peptide (ANP) were reported. Leppaluoto *et al.*[36] evaluated ANP concentration in six healthy persons following a single use of Finnish sauna bath. Exposure duration was 20 minutes and blood samples were collected during sauna bath and in the 20th, 60th, 90th and 120th minute after the sauna cabin was left (the volunteers remained in the sitting position in a room at a temperature of 22°C). During heat exposure, the authors did not observe any changes in ANP level, while a decrease in right ventricular blood pressure was observed. ANP concentration increased as late as in the 60th and 120th minute following termination of heat exposure; no changes in BP or HR were observed during this period of time. Systematic two-week "infrared" dry sauna baths, applied in patients with chronic heart failure, did not induce significant ANP or catecholamine changes but resulted in a significant reduction of brain natriuretic factor (BNF) and significantly decreased the incidence of premature ventricular beats. In these studies, the effect was not evaluated in a control group of healthy persons[1,61]. Studies conducted on patients with risk factors for coronary artery disease and patients with chronic heart failure have demonstrated an improvement in endothelial function following dry "infrared" sauna[2,9,62]. The authors suggest that regularly performed heat exposure in sauna over a period of two weeks may increase both activity and expression of the endothelial nitric oxide synthase (eNOS)[2].

Changes in neuro-humoral activity as well as in haemodynamic variables observed in sauna may depend on body position assumed during measurements: supine, sitting or standing[20,29].

RESPONSE OF THE CARDIOVASCULAR SYSTEM TO COOLING OFF APPLIED DURING SAUNA USE

Standard Finnish sauna bathing involves alternating heating and cooling of the body repeated 2 or 3 times and followed by a rest, when cardiovascular system activity normalises. Thirty minutes after termination of exposure, heart rate is still slightly elevated while blood pressure reaches baseline values.

If cooling off involves immersion of the whole body into cold water, skin temperature abruptly falls to 33°C[27]. Sudden exposure of the organism to intense cooling induces immediate cardiovascular system changes[63]. Cold receptors located in the skin are acivated resulting in activation of the sympathetic skin response and in an increase in blood catecholamine levels[63]. Sympathetic system activation results in vasoconstriction. Venous return to the heart is increased thus augmenting preload. There is an increase in end-diastolic pressure in the left ventricle and the stroke volume. Total peripheral resistance and blood pressure also increase[24,64]. All these factors cause an abrupt increase in cardiac work despite a reflex decrease in heart rate. The above changes were observed both in persons with normal blood pressure and in patients with hypertesives[29].

Immersion in ice-cold water of only one hand for 1 minute (cold pressure test) elicited a rise in blood pressure, heart rhythm disturbances and constriction of a coronary artery at a site of pre-existing atherosclerotic plaque. Both depression and elevation of the ST-segment were reported in the electrocardiogram[29,65]. It was demonstrated that application of cold water onto the head or face increases the risk of heart dysrhythmia, while immersion of the head in cold water immediately after laving sauna cabin can even lead to death caused by sudden coronary artery vasoconstriction[29,66].

Abrupt immersion of the whole body in cold water immediately after leaving sauna room, can evoke a marked increase in peripheral resistance and thus even a critical rise in blood pressure[25].

The above changes increase both afterload and preload of the heart and increase myocardial oxygen demand.

Potential coronary vasospasm additionally augments the disturbances in equilibrium between oxygen demand and supply to the working myocardium[63] thus increasing the risk of arrhythmia, myocardial ischaemia and infarction[29,51]. Patients with atherosclerotic changes in the coronary arteries are particularly exposed to such complications. Therefore, cooling off evoked by immersion of the whole body should be considered individually for each sauna user[67]. In healthy persons, undesirable effects on the cardiovascular system occur rarely[29], whereas cold water immersion should be resigned on in patients with cardiovascular diseases and gradual cooling of the organism, e.g. using a shower, should be applied or such person should remain outside sauna and be protected from rapid loss of warmth[2]. In this group of patients, to avoid a hypotensive reaction, fluid replacement is recommended after leaving sauna room and exercises involving performance of several flexion and extension movements in the ankle joints may be performed[15].

CHANGES IN RHEOLOGICAL PROPERTIES OF THE BLOOD

Studies conducted *in vitro* demonstrated changes in rheological properties of the blood following a sauna bath. Single stay in sauna induces an increase in blood viscosity by 13-40% in occasional sauna users[68]. According to Ernest, this change is likely caused by a reduction of intravascular fluid volume and the relative increase in the volume of morphotic elements of the blood. Statistically significant increase in plasma viscosity was accompanied by an increase in the haematocrit and erythrocyte and leukocyte counts[68].

In systematic sauna users, the increases in blood viscosity (by 2-8%), γ-globulin level, leukocyte and erythrocyte counts, and in haemoglobin concentration are limited. With more frequent sauna use, albumin concentration was decreasing[68].

UNDESIRABLE CARDIOVASCULAR REACTIONS

The risk of cardiovascular complications induced by sauna is low in healthy persons[29]. Most frequently, this risk is associated with a latent disease of the cardiovascular system.

Sudden death is the most serious complication associated with sauna bathing (with the effects of high temperature and cooling on the organism). Autopsies conducted within 1 year in Finland (a population of approximately 4.5 million people for 1.4 million of saunas / data as of 1988) demonstrated that 67 deaths occurred during a sauna bath or within 24 hours after use of sauna. Mean age of males who died was 54 years and of females – 64 years. In 58 cases, the cause of death was associated with previously undiagnosed ischaemic heart disease, in 7 persons – acute heart failure, and in 2 – cerebrovascular disease. This implies that in the majority of cases, death occurred in patients with already present cardiovascular disease[29]. In the population of Helsinki, where mean frequency of sauna use is higher than once a week, in 8 of 1631 deaths due to an acute coronary event, the onset of symptoms occurred during and in 13 cases – within three hours after sauna use (21 / 1631 = 1.3%)[61]. Luurila[17] concluded, based on own observations and an analysis of the available publications, that the risk of sudden death during sauna use is lower than during standard activities of daily-living.

Abrupt body cooling in cold water or in snow is one of the risk factors for complications, especially in the elderly with diseases of the cardiovascular system or a tendency to arrhythmia[29]. The risk of cardiac events is increased when alcohol is consumed during or before the exposure to high temperature[29,69-71]. Use of alcohol in the sauna increases the risk of sudden fall in blood pressure and syncope[71], occurrence of heart rhythm disturbances[72] and sudden death, especially in patients with coronary artery disease[25,60]. The majority of deaths (86%) that occurred as a result of sauna baths in years 1970-1986 in Finland were due to use of sauna under the influence of alcohol[73]. The danger associated with sauna increases when sauna bath is used for a period of time longer than the recommended, which is most frequently used as a method of body weight reduction[39,51,52,74,75]. Some athletes, to reduce body weight, combine the warmth therapy in sauna with concomitant use of diuretics thus exposing themselves to complications[5].

SUMMARY

Cardiovascular changes occurring during sauna bath depend on air temperature, duration of exposure, humidity, fluid balance and presence of diseases of the cardiovascular system, especially the ischaemic heart disease. Exposure of the organism to heat induces changes in the cardiovascular system that primarily aim at protection of the organism from overheating. Principle reactions include cutaneous vasodilatation and increase in skin blood flow; changes in blood flow in other vascular beds are compensatory and involve neuro-humoral mechanisms. Changes in endothelial reactivity, blood pressure and heart rate occurring during heating can have a beneficial effect on heart function. This effect, however, depends on temperature and humidity load as well as on body position in sauna and on individual organism adaptation to high temperature. Intensive and long-term stay in sauna can cause cardiovascular complications. Rapid cooling off is associated with a particular risk of occurrence of cardiovascular complications, including coronary events. Percentage of complications elicited by sauna bath is small and refers primarily to persons with coronary artery pathology, using drugs, e.g. diuretics, as well as to persons consuming alcohol and persons applying excessive heating or cooling.

List 1

GENERAL GUIDELINES PERTAINING TO USE OF SAUNA BATH BY PATIENTS WITH CARDIOVASCULAR DISEASES[15]

May be used in:
- patients from the low-risk group (stable angina pectoris, well-controlled hypertension, compensated cardiovascular disease), used to sauna baths.

Contraindications:
- patients, who may experience damage resulting from a reduction in stroke volume and/or a fall in arterial blood pressure
- patients with uncompensated heart failure
- patients with advanced aortic valve stenosis
- patients with unstable angina pectoris
- patients with poorly controlled hypertension
- patients immediately after performance of intense physical exercise
- patients, who consumed alcohol

The above guidelines should be applied individually for each patient.

List 2

GENERAL GUIDELINES FOR PATIENTS WITH CARDIOVASCULAR DISEASES, WHO USE SAUNA BATHS

- After heart infarction, patients may use sauna after 6-8 weeks
- Temperature in the sauna room should not exceed 60-80°C
- After having entered the sauna cabin, patients should sit on the lowest bank for 2-3 minutes in order to prepare the organism for high temperature, subsequently, they may transfer to an upper bank
- During the stay in sauna cabin, the heated stones should not be poured with cold water, as this enhances the intensity of organism heating
- Single heat exposure should not last longer than 5-10 minutes; in persons accustomed to sauna use, duration of the exposure may be prolonged to 15 minutes
- After leaving the sauna, several minutes of rest in a sitting position is recommended, followed by gradual body cooling
- Cooling off involving immersion of the whole body in water or rubbing / rolling in the snow must not be performed
- Depending on patient's general feeling, alternating body heating and cooling performed during a single bath may be applied two to three times
- Rest following the whole sauna procedure should last 10-15 minutes
- Following termination of sauna bath, it is recommended to drink and perform exercises in the ankle joints involving several flexion and extension movements.

The above guidelines should be applied individually for each patient.

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