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EFFECT OF 30-MINUTE SAUNA SESSIONS ON LIPID PROFILE IN YOUNG WOMEN

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Abstract

Objective: To determine changes in lipid metabolism in young females during single and repeated bath sessions in Finnish sauna.

Methods: Nine healthy non-smoking females (20-22 years) were exposed to seven 30-minute sauna baths every two days, in the morning, in temperature 91°C and humidity 15,6%. The first session was scheduled for follicular phase of the menstrual cycle, whereas the last bath occurred during luteal phase. In blood samples collected before the 1st and the last sauna bath and immediately afterwards haematocrit (Hct), haemoglobin (Hb) and free fatty acids (FFA), triacylglycerols (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low density lipoprotein cholesterol (LDL-C) were analyzed. The rectal and tympanic temperatures were taken by means of Ellab electrothermometer.

Results: Rectal temperature was lower in the last sauna bath than in the first one, which consequently leads to body acclimation. Losses of plasma were greater during the seventh bath than during the first one. Increase in FFA concentration can be observed after a single and repeated sauna session, which may confirms the intensified lipolysis caused by elevated secretion of hormones that activate lipolytic enzymes.

Conclusions: Reduction in TC and LDL-C concentrations was observed in women after 2 weeks of repeated sauna sessions. These changes can be a good prognosis in prevention of ischaemic heart disease.

Keywords: *body acclimation, lipid profile, thermoregulation, rectal temperature, Finnish sauna*

Introduction

Sauna bathing belongs to a group of physical therapy methods used in athletic recovery and represents a specific combination of body overheating using a hot and dry air, short effect of high humidity and strong electric field intensity followed by body cool down by means of air bath or cold water. Finnish sauna bathing have gained popularity in recent years as a form of heat therapy, used for prevention and hygiene purposes and athletic recovery [1-4]. When staying in sauna, skin temperature and consequently core body temperature increase. Increase in core body temperature above the set point in hypothalamus releases a series of reactions in order to control heat balance in the body. The most effective mechanism for elimination of excess heat in the body when staying in the environments with ambient temperatures higher than body temperature is sweating and evaporation of sweat from the skin surface [2-4].

Efficient function of the thermoregulatory system is correlated with the activity of almost all physiological systems in human body. Therefore, the thermoregulatory system is not an autonomous body system [5].

Blood and cardiovascular system are also critical to body thermoregulation. Circulating blood stabilizes temperature in individual vascular regions. Moreover, it is a very important agent between body interior, locations of heat production or the skin surface and the locations of heat release from the body [5].

A system which has particular effect on lipid metabolism is the endocrine system. Sauna bathing causes metabolism rate to increase as a result of stimulation of sympathetic adrenergic system, hormonal changes and core body temperature [6,7].

There is little information in the literature on changes in metabolism in women [8,9] induced by higher ambient temperature and it has not been decided yet what is the mechanism of changes in carbo-

hydrate and fat metabolism in specific conditions of overheating body in Finnish sauna.

The goal of the study was to determine changes in lipid profile in young females during single and repeated bath sessions in Finnish sauna.

Methods

The study covered the period from January to March. Nine healthy non-smoking females, aged 20-22 years participated in the study. The women were all non-athletes and had never been in sauna before. They also had not taken any hormonal medication and nutritional supplementation for two years prior to the study. The project was approved by the Bioethical Committee at the Regional Medical Chamber in Krakow (No. 202 KBL/OIL/2003).

Before the examination was started, the following anthropometrical indices were measured: body height [BH], body mass [BM], Qetelet index [BMI], body surface area [BSA], body density [D], body fat percentage [%F] and lean body mass [LBM]. The method of interview concerning their diets within past 24 hours for 6 days (5 weekdays and one weekend day) [10] was also employed for the study. The amount of consumed portions was evaluated based on Pictured Book of Products and Foods [11]. The data collected during the interviews were used for the determination of the subjects' diets using the dedicated software Wikt 1 and Tables of Nutritional Values in Foods [12]. When calculating the nutritional value of meals, the authors took into consideration the coefficients of loss connected with technological processes. The contents of selected nutritional components and the energy values were obtained, of which mean values of the six analysed days of individual diets were calculated for each woman.

The female volunteers participated in seven Finnish sauna bathing sessions every two days in the morning. The first session was scheduled on the 6 day of the menstrual cycle, whereas the last bath occurred during the second luteal phase. Each session took 30 minutes, followed by a 5-minute cool-down in the shower with water temperature of 20–21°C and then relaxed in half-sitting position. The temperature in the sauna room measured at the height of the head was 91°C±2°C, whereas the relative air humidity was 15.6%±4%.

Physiological measurements and biochemical tests were carried out on the first day of the study, before and after the sauna bath and on the last (fourteenth) day of the study, similar to the first examination. On these two days, the subjects took part in the experiment on empty stomach after the night's sleep. The last meal and drink was taken before 10 p.m. on the previous day. The rectal and tympanic temperatures were taken by means of electrothermometer (Ellab, Denmark) with accuracy of 0.1°C. Body mass was measured before and after the heat exposure was completed by means of Sartorius F 1505 – DZA electronic scale (Germany).

Blood samples for biochemical tests were taken from cubital vein with the volume of 10 cm^3, 10 minutes prior to and immediately after the sauna bath and after the next 24 hours. Blood haematocrit (Hct) was measured by means of the microhaematocrit method, whereas determination of the haemoglobin concentration (Hb) was carried out using Drabkin's method.

Haematocrit and haemoglobin levels were used for calculation of changes in plasma volume according to Dill's and Costill's formula [13] modified by Harrison et al. [14].

$$\% \Delta PV = 100 \{(Hb_1/Hb_2) * [100 - (Hct_2 * 0.874)] / [100 - (Hct_1 * 0.874)] - 1\}$$

Where Hb_1 (g/dl) and Hct_1 (%) are initial values, whereas Hb_2 and Hct_2 are final values.

The following levels were also determined in blood serum: free fatty acids (FFA), triglycerides (TG), total cholesterol (TC) and high-density lipoprotein cholesterol (HDL-C). These indices were determined using test batteries manufactured by Biochemtest, POCH Gliwice (TL), P.Z. Cormay, Lublin (TG and TC), bioMérieux, France (HDL-C) in a laboratory in the Department of Clinical Biochemistry at the Paediatric Institute in Jagiellonian University Medical College in Cracow. The concentrations of lipid profile indices were corrected so as to allow for heat stress-induced changes in plasma volume [15]. Kraemer's and Brown's formula [16] was employed to calculate the corrected levels.

$$W_{sk} = (\%\Delta PV \cdot 0.01 \cdot W_{po}) + W_{po}$$

Where: W_{sk}-corrected level
W_{po} -level after the exercise or sauna bath

Statistical analysis

The measured values were presented as means ± SD. Statistical significance of the differences between the obtained results was verified using Wilcoxon's test for two dependent samples by means.

Results

Anthropometrical measurements of the women studied (Table 1) were consistent with the standards adopted for young women aged 19-20 years.

Changes in individual physiological indices as a result of sauna-induced hyperthermia are presented in Table 2.

When overheated in sauna, body's dehydration occurred in women studied, which resulted in significant body mass reduction during both bath sessions ($P < 0.05$). Dehydration contributed to blood densification,

Table 1. *Indices of calendar age and body morphology in the women studied*

Index	$\bar{x}$ ± SD
Age [years]	19.8±0.92
Body Height – BH [cm]	163.9±4.72
Body Mass – BM [kg]	58.36±5.81
Body Mass Index – BMI [kg/m^2]	21.7±*1.62*
Body Surface Area – BSA[m^2]	1.63±*0.1*
Body Density – D [g/mm^3]	1.04±0.03
Body Fat Percentage – % F (%)	23.18±4.61
Fat Mass – FM [kg]	13.61±3.59
Lean Body Mass – LBM [kg]	44.75±4.32

Table 2. *Changes in physiological indices after exposure to heat in Finnish sauna*

Parameter	1st sauna bath			7th sauna bath		
	Before (1)	After (2)	Δ (2-1)	Before (1)	After (2)	Δ (2-1)
BM [kg]	58.36±5.81	57.80*±5.81	-0.56	58.57±5.72	58.0*±5.65	-0.51
Hct [%]	41.15±1.03	42.95*±1.12	1.8	41±2.27	42.5*±2.04	1.5
Hb [g/l]	13.72±0.64	14.55*±0.99	0.83	13.9±1.04	15.02*±0.89	1.16
Ttym [°C]	37.0±0.2	39.3*±0.5	2.3	36.8±0.3	38.7*±0.3^	1.9
Tre [°C]	37.3±0.3	38.4*±0.4	1.1	37.1±0.3	38.1*±0.6	1.0
Δ % PV			-8±4.6^	0.3%±0.2		-9.5^±6.4

*$P < 0.05$ difference before and after sauna bath
^ $P < 0.05$ difference between the 1st and 7th sauna sessions

Table 3. *Changes in lipid profile in blood plasma after sauna bath in the women studied*

Parameter	1st sauna bath					7th sauna bath				
	Before (1)	After (2)	Δ (2-1)	After 24h (3)	Δ (3-1)	Before (1)	After (2)	Δ (2-1)	After 24h (3)	Δ (3-1)
TG [mmol/l]	0.74 ±0.29	0.75 ±0.27	0.01	0.81 ±0.24	0.07	0.96 ±0.54	0.89 ±0.33	-0.07	0.83 ±0.33	-0.13
TC [mmol/l]	4.47 ±0.85	4.53 ±0.78	0.06	4.58 ±0.86	0.11	4.25^ ±0.93	4.37 ±0.91	0.12	4.08 ±0.80	-0.17
HDL-C [mmol/l]	1.29 ±0.31	1.35 ±0.27	0.06	1.38 ±0.32	0.09	1.34 ±0.17	1.34 ±0.19	0.00	1.38 ±0.21	0.04
LDL-C [mmol/l]	2.83 ±0.80	2.82 ±0.76	-0.01	2.80 ±0.86	0.02	2.69^ ±0.83	2.74 ±0.82	0.05	2.51 ±0.71	-0.18
FFA [mmol/l]	0.69 ±0.28	1.07* ±0.12	0.38	0.81 ±0.18	0.12	0.62 ±0.20	0.84* ±0.34	0.22	0.68 ±0.12	-0.06

* $P < 0.05$ difference before and after sauna bath
^ $P < 0.05$ difference before 1st and 7th sauna bath

Table 4. *Mean daily energy values and nutritional intake in the diets of study participants*

Energy [kcal]	2956±534.16
Proteins [g]	104±28.62
Fat [g]	111±26.48
Carbohydrates [g]	407±73.70

expressed by a significant ($P < 0.05$) increase in haematocrit number and haemoglobin concentration and considerable reduction in plasma volume. The values of indices that reflected dehydration (concentrations of Hb, Hct and Δ% PV) were significantly higher during the seventh sauna session. Regular sauna sessions caused an insignificant increase (by 0.3%) in plasma volume in the women studied. High ambient tempera-

ture in the sauna chamber contributed to a significant ($P < 0.05$) increase in rectal and tympanic body temperature in the women studied. Lower increase in both temperatures was observed during the last session, which is undoubtedly the effect of acclimation caused by regular hot bath sessions.

Body overheating induced insignificant changes in lipid profile in the women included in the study (Table 3). Significant reductions ($P < 0.05$) in total cholesterol and LDL cholesterol fraction were observed after seven sauna sessions. Furthermore, significant increases ($P < 0.05$) in concentration of free fatty acids were observed after each sauna session. Mean daily energy values and nutritional intake were consistent with the standards for young women (Table 4).

Discussion

The results from a number of population-based studies show that the most (70%) of Poles aged 20 to 74 years, living both in cities and in rural areas, have dyslipidaemia. Abnormal (higher than standard) cholesterol levels (above 190 mg/dl) and/or LDL-cholesterol (above 115 mg/dl) were found in 67% of men and 64% of women [17,18]. Since lipid concentration in blood is affected by many factors, such as genetic determinants, nutritional habits or level of physical activity, it is difficult to say definitely which of them have effect on this frequent occurrence of lipid disturbances in Polish population. Changes in nutritional habits, lower economic status of society might also be conducive to lipid disturbances. Level of physical activity is also essential. Sadly, it is being reduced in Polish population, often for purely economic reasons. Movement deficiency and high energy diets cause metabolic disturbances which often lead to the increase in body fat and elevated cholesterol levels and its lipid fractions in blood [19].

A leading factor which determines proper lipid metabolism is systematic physical activity. The lack of physical activity adversely affects lipid metabolism indices (total cholesterol, HDL cholesterol, LDL cholesterol, triglycerides, Apo-A1 and Apo-B). Low physical activity or its lack, particularly combined with higher psychical stress might be a reason for premature arteriosclerosis, which manifests in elevated LDL cholesterol, VLDL cholesterol and triglycerides and reduction in HDL cholesterol [20-22]. Numerous studies have demonstrated that, apart from physical exercise, diets have also a substantial effect on lipid metabolism indices. A positive correlation was found between HDL fraction and some products consumed in diets [22]. Beneficial changes in LDL/HDL ratio after repeated cryotherapy sessions were demonstrated by Lubkowska [24]. In a study which examined the patients with coronary heart disease, the authors demonstrated reduced levels of total cholesterol, triglycerides and LDL cholesterol after regular yoga sessions [25]. There were also reports which found that sauna overheating could lead to positive changes in blood plasma lipid profile [9].

Under conditions of considerably higher ambient temperatures, heat loss with sweat is the only efficient mechanism of release of heat from the body. During a typical sauna session, average volume of water lost from the body amounts to ca. 400-600g [6,26,27]. Dehydration of the body is reflected by the loss of body mass and reduction in plasma volume. Mean body mass decrease observed during the experiment present in this study was 0.55 kg. This decrease was lower than changes observed in similar experiment carried out among men [28] and changes in men reported by Finnish authors [29]. These differences can be explained by the fact that women are characterized by lower water content in the body and thicker subcutaneous fat compared to men, which causes that they start sweating later than men and the intensity of sweating is much lower. Accordingly, body mass loss is usually lower in women and the increase in body temperature higher than in men [27,30].

If exposure to higher temperature is continued, heat starts to accumulate in the body, even despite the most efficient thermoregulatory mechanisms. Temperature measurements show a progressing profile of core body temperature. During a sauna bath, body temperature might increase by from 0.5 to 4.0°C, never reaching 40°C [31]. In the present study, rectal and tympanic temperatures during sauna sessions were elevated. The results obtained for Tre and Tty were consistent with the results reported by other authors. An increase in rectal temperature by 1.3°C after 30-minute exposure to heat in sauna was observed in a series of tests carried out between men and women [32].

Mean tympanic temperature in the women studied during follicular phase of menstrual cycle, observed before the first sauna bath, was lower than mean rectal temperature. Similar initial values and levels of tympanic and rectal temperatures and similar relationships between the discussed initial values (Tty<Tre) were observed in other experiments, either in men and in women [33]. Initial Tty in the subjects was similar to the results obtained by Frascarolo et al. [34] in women during follicular phase. Mean values of Try and Tre observed in women before seventh sauna session, which occurred in luteal phase, did not differ from the temperatures observed in the beginning of the experiment. Core body temperature in the luteal phase is usually higher (by ca. 0.4%) compared to the follicular phase [35]. This was confirmed with respect to Tty by Frascarolo et al. [34]. Higher basal body temperature in the luteal phase is a result of a shift of the set point in body's thermoregulatory system to the higher level (34). Consequently, the threshold of sweat-

ing and cutaneous vasodilation is shifted upwards [35]. Lack of significant differences in basal values of the temperatures between follicular and luteal phase in this experiment can be explained by the likelihood of temporary disturbances in the menstrual cycle in the women studied (delayed ovulation or an anovulatory cycle) induced by repeated heat stress. Leppäluoto et al. [36] observed 2 to 5-weeks delay in menstruation in five of seven women who repeated sauna sessions for seven days. Ovulation disturbances in women who were exposed to heat stress in sauna might result from hyperprolactinaemia, which was observed in the experiment carried out by Pilch et al. [37] also reported by other authors [38]. Disturbances in menstrual cycle might also result from heat stress-induced elevated secretion of β-endorphins [39].

Heat-induced body dehydration was the cause of reduction in plasma valume. Assuming that average plasma volume in women is ca. 2.500 ml, the average plasma reductions were 200 to 237 ml. Compared to changes in body mass, it is remarkable that the most of water lost with perspiration was from extravascular space. When sweating intensifies, a considerable loss of liquids occurs primarily in extracellular space [35]. Further loss of liquids involves also loss of water from cells, leading to a reduced plasma volume. Numerous authors have demonstrated that dehydration, either as a consequence of passive overheating or as a result of physical exercise, leads to loss of water from both cells and extracellular space [40,41].

Sauna bathing causes increased rate of metabolism that results from stimulation of sympathetic adrenergic system, hormonal changes and elevated body core body temperature [6,7]. There are few studies in the available literature that have examined the metabolic response induced by elevated ambient temperature and it has not been determined to date how the changes in metabolism occur under specific conditions of body overheating in Finnish sauna. The hormonal effect on lipid metabolism mainly concerns the regulatory effect on the rate of synthesis of key enzymes and modified activity of these enzymes [21]. Rate of lipid transformations might change slowly within several days and even weeks or very fast, within several minutes [22]. Concentration of main hormones that regulate lipid metabolism in blood plasma might change throughout the day (insulin, glucagon, cortisol, hormones in gastrointestinal tract) or regardless of the time of the day e.g. after meals and in stress, when rapid changes in secretion of some hormones might occur. The modification of lipid metabolism observed in the present study might have been affected by rapid hormonal changes that were observed in other study by Pilch et al. [6,7].

No changes in total lipids or triacylglycerols (TG) were observed in the present study after a single and repeated sauna sessions. The effect of heating on the level of TG has not been determined definitely to date as some authors demonstrated an increase in concentration of these lipids in men after a single body overheating in sauna [42] while others observed no changes [43]. A statistically significant increase in concentration of free fatty acids (FFA) was observed after a single sauna session and insignificant increase after the last one. The factors which intensify lipolysis in adipose tissue and thus reduce the FFA levels in blood include glucagon, catecholamines, ACTH, cortisol and sympathetic nervous system. Glucose and insulin are the factors which inhibit lipolysis and stimulate lipogenesis. Increased secretion of lipolytic hormones such as hGH, ACTH, cortisol and prolactin which can be responsible for the increase in FFA were observed in a similar experiment [6,7,37]. Increased secretion of catecholamines and glucagon and excitation of autonomic nervous system described by other authors are also the factors which stimulate lipolysis under conditions of heat stress [38]. Inhibited insulin secretion and deteriorated insulin response to glycaemia are the factors that reduce lipogenesis [44] a process that reduces FFA levels in peripheral blood. Therefore, an increase in FFA concentration induced by overheating in sauna might results from both intensified lipolysis and reduced lipogenesis. The factors which should be emphasized as risk factors in ischaemic heart disease are changes in cholesterol fractions induced by a single and repeated sauna sessions. The present study found a decrease in total cholesterol concentration measured on empty stomach before sauna sessions and in LDL cholesterol after 2 weeks of repeated sauna sessions. These changes might be a good prognosis in prevention of ischaemic heart disease because a positive relationship between total cholesterol levels and the incidence of ischaemic heart disease has been demonstrated [45]. Similar relationship exists between the level of LDL cholesterol (often informally called 'bad cholesterol') and incidence of ischaemic heart disease, whereas the opposite correlation occurs between HDL cholesterol and this heart disease [45].

It is impossible to draw definite conclusions and unequivocally interpret the changes in lipid fractions in blood plasma based on the examinations presented in this study. Another difficulty is the lack of sufficient data in the available literature. However, further research need to be carried out into the effect of sauna on fat metabolism, with particular focus on the people with improper lipid indices.

Conclusions

The following conclusions can be drawn from the results of the present study:

1. Lower increase in rectal and tympanic temperature after a series of sauna sessions points to facilitation

of thermoregulatory mechanisms, which consequently leads to body acclimation.
2. Greater reduction in blood plasma observed in the last sauna session might suggest elevated activity of thermo effectors, which is connected with adaptive changes in thermoregulatory mechanisms.
3. A considerable increase in FFA concentration can be observed after a single and repeated sauna session, which confirms the intensified lipolysis
4. A reduction in total cholesterol and LDL cholesterol concentrations was observed in women after 2 weeks of repeated sauna sessions.
5. These changes can be a good prognosis in prevention of ischaemic heart disease.

Declaration of interest

The authors report no conflicts of interest.

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