

The Effects of Finish Sauna on Hemodynamics of the Circulatory System in Men and Women

by

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Finnish sauna is one of the most popular among all the saunas types and as a result is the most commonly used. Bath in the Finnish sauna is a combination of heating with a warm and dry air and the short influence of high humidity and cooling with cold water and air. The article aims to identify pulse and blood pressure in the conditions of thermal heating in the sauna among women and men between the age of 20–25. Hypothetically sauna has a great influence on the basic hemodynamic parameters such as pulse and blood pressure. There were 127 healthy, young women and 74 men, students at the University of Physical Education in Wrocław taking part in the experiment. Average age of the volunteers was 21.5 and 21.7.

The results indicate that a bath in the Finnish sauna leads to a significant increase of the pulse among men and women. Concurrently the results show a considerable decrease in diastolic pressure, with the systolic pressure remaining at almost the same level. It can be concluded that a bath in a Finnish sauna positively influences the hemodynamics of blood pressure and pulse. A series of bathes in the Finnish sauna leads to a considerable decrease of the systolic and diastolic pressure and an increase of the pulse among male and female volunteers.

Key words: hemodynamics, pulse, systolic pressure, diastolic pressure, Finnish sauna

Introduction

Sauna is a form of treatment which comprehensively affects the whole body, therefore it is very popular all over the world. It occupies a prominent place in the offer of various health and fitness centres, beauty parlours and more and more frequently it may also be found in private homes (Szyguła 1995). Sauna is classed as a biomedical kind of health and beauty treatment used in competitive and recreational sports as well as a therapy. During a sauna bath the hot and cold air alternately affects the body causing a variety of reactions (Groves 1987, Chorąży,

Kwaśny 2003). Those different reactions in the first and second phase of the treatment have specific effects which do not sum up as one stimulus (Straburzynska-Lupa, Straburzynski 2003).

The observed changes taking place under the influence of sauna depend mainly on individual thermoregulatory reactions, age, sex, efficiency of the circulatory and respiratory system, individual likes and preferences as well as traditions related with the use of the Finnish sauna (Bromboszcz, Dylewicz 2006).

The most popular and the most frequently used form of sauna is the Finnish sauna. The sauna ses-

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sion is a treatment combining warming up the body by means of hot, dry air with short – term effect of high humidity and cooling the body down by cold water and air (Tanny 1995). Its effects on health and beauty are invaluable. The sauna is recommended mainly in order to relax after physical exercise, soothe various pain problems or clear the body of toxic substances which are absorbed from the natural environment. It was proved that using the sauna regularly increases the capabilities enabling one to adapt to the variable environmental conditions as well as to physical effort and it positively influences psycho-emotional features of a person (Pilch et al. 1994).

There is a wide range of medical indications for the sauna. However, one should remember that there are also contraindications (Brzostek et al. 2007). Unfortunately, sometimes the sauna is applied inappropriately. For example some sportsmen use the sauna to rapidly reduce their body mass (so called “weight trashing”) and also in order to adapt the body to exercise in higher temperature. The negative consequences of dehydration and possible health-related complications mean such practice is strongly criticised not only by doctors, but also by physiologists, physiotherapists and some trainers (Straburzyńska-Lupa, Straburzyński 2003).

While analysing the aforementioned observations it would be advisable to clarify what hemodynamics actually is. The term embraces a field of science concerning blood flow in the cardiovascular system. It is a mechanical heart function which enables blood flow through blood vessels. The circulatory system is indispensable for transporting oxygen and nutritive substrates to the tissues and for removing carbon dioxide as well as metabolism by-products from the body, and it also participates in immunological reactions, hormones transportation and regulation of the body's temperature through the cutaneous blood flow.

The main aim of the paper was to evaluate the adaptation of the circulatory system to sauna conditions and cooling of the body as well as to indicate some practical dispositions. The research group consisted of healthy students.

Sauna baths affect the body in a variety of ways. Apart from increasing the temperature of the body, they also influence the endocrine glands, especially the adrenal glands, stimulated by both the hypothalamus – hypophysis – adrenal glands system and the renin – angiotensin – aldosterone system.

Sauna sessions significantly impact the respiratory system which results in improving of the blood supply of the mucous membrane of the upper airways, increasing of the vital lung capacity as well as of the tidal volume and minute ventilation equivalent, increasing of the forced expiratory volume in one second and decreasing of the elastic resistance of the lung tissue (Pilch et al. 2006, Hanninen 1986).

The Finnish sauna also positively affects the motor system, improves elasticity of the fibrous tissue of the articular capsules and ligaments as well as the blood flow in periarticular elements. It reduces the viscosity of the synovial and relaxes skeletal muscles as well as adhesions and increases the joints' mobility range (Brzostek et al. 2007).

Positive and long-lasting effects can be achieved when the sauna is used regularly. Most of all it helps to gain mental relaxation, improvement of the respiratory system efficiency, stimulation of the endocrine glands and immunological system, increasing of muscle strength and relaxation of the joints, stimulation of the heart rate and of the circulatory system (Adamczyk-Bujniewicz et al. 2003). Moreover, under the influence of the thermal variability of the sauna sessions the concentration of cortisol from the group of, so called, stress hormones increases. The increased level was observed after each sauna treatment, however, on the last day of the research a lower increase of cortisol was found which means that the thermal conditions in the sauna were not as stressful for the examined as anticipated (Pilch et al. 1994).

In conclusion it may be said that the thermal balance of a person submitted to the sauna is influenced by various factors which include: temperature, humidity, air movement, time of exposure to high temperature, relation of the body surface to its mass, cutaneous blood supply, the amount of secreted sweat (Tab. 1).

The influence of traditional sauna on the human body has been the subject of numerous researches (Bromboszcz, Dylewicz 2006, Kauppinen et al. 1986, Trojnacka 2008). The authors of the paper are mainly interested in the variability of the pulse and arterial blood pressure under the sauna's influence. Observing the process of adaptation of the circulatory system to sauna conditions and to alternating warming up and cooling down of the body plays an important role here as this treatment is used not only by young and healthy people, but more and more

Table 1

<i>Factors that affect human body during the sauna treatment</i>		
Before sauna treatment	In the heating phase	In the cooldown phase
Hot water on feet	Low humidity and high air temperature. After pouring water on stones there is a temporary increase of humidity and high air temperature.	Cool air. cool or cold water.

frequently by the elderly in whom the risk of cardiovascular diseases is higher (Brzosek et al. 2007).

The aim of the research was to monitor the pulse and arterial blood pressure in conditions of overheating in the sauna in a group of men and women aged 20–25.

It may be hypothetically assumed that sauna treatments greatly influence the basic hemodynamic parameters, such as the pulse and arterial blood pressure.

In order to verify the constructed hypothesis the following research questions were posed:

- Does arterial blood pressure and pulse change significantly after overheating in a sauna ?
- Does arterial blood pressure and pulse measured after sauna treatments vary in men and women?

Material and Methods

The research group consisted of 127 healthy women and 74 men – students of the University of Physical Education in Wroclaw, Poland (Tab. 2). The mean age was 21.5 and 21.7 respectively. The volunteers declared that they did not practise any competitive sports.

The research was carried out in the morning (from 8 am to 12.30 pm) once a week during the biological renewal courses in the spring and autumn semesters in 2007/2008 academic year. All the examined had been informed about the procedures and agreed to take part in the experiment.

The participants of the experiment took sauna sessions on empty stomach and with emptied urinary bladder. Prior to entering the sauna room they had washed with warm water and then dried carefully.

Each sauna session consisted of three phases:

Phase one: direct overheating: air temperature in the sauna room – 115°C, humidity – 35%, time spent in the sauna room – 12 minutes,

Phase two: cooling by submerging the whole body three times under water of 10°C,

Phase three: passive relaxation for 24 minutes.

Measurements of the pulse and blood pressure were taken on the left arm by means of a manometer M4 by OMRON Matsusaka, Japan before the session, after the first, second and third visit in the sauna and after the cooling phase. The measurements' accuracy was repeatedly verified by means of a mercurial manometer. The results were registered in a protocol (Tab. 3).

Results

The statistical analysis were carried out by means of the Statistica V8.0 software.

A statistically significant decrease of the arterial blood pressure and an increase of the pulse after overheating in the sauna room in men and women are both important research results ($p \leq 0.05$). These parameters were also analysed after the first, second and third sauna bath followed by the cooling phase.

Table 2

<i>Age and somatic parameters of men and women participating in the research</i>						
Variable	Women (N = 100)		Men (N = 73)		Student's T-test	
	\bar{x}	S	\bar{x}	S	t	p
Age [years]	20,99	0,67	21,42	1,30	-2,86	0,0048
Body height [cm]	167,13	6,05	181,60	6,07	-15,53	0,0000
Body mass [kg]	57,52	7,80	77,54	10,43	-12,50	0,0000
BMI	20,55	2,22	23,54	2,34	-7,36	0,0000

<i>Record of the research</i>												
Lp	Name Surname	Sex (F/M)	Age	Weight	Before treatment		After I treatment		After II treatment		After III treatment	
					0		1		2		3	
					T	RR	T	RR	T	RR	T	RR

The following numeration was used in the paper:

- Before the treatment
- After the first sauna session and the cooling phase,
- After the second sauna session and the cooling phase,
- After the third sauna session and the cooling phase.

The arithmetical mean values (\bar{x}) of the pulse and arterial pressure in the research group before the treatment were within the normal range (Tab. 4). The analysis of hemodynamics before the treatment indicates higher systolic and diastolic pressure in the group of men (147.56 and 79.88 mmHg respectively), whereas in the group of women higher mean values of the heart rate were observed (80.82 beats per minute). The results are compatible with the physiological norm. The evaluation of the changes in the arterial blood pressure and pulse before and after the sauna treatment is presented in Table 6. The statistically significant differences are presented in bold.

The statistical results presented in Table 4 indicate that the average systolic blood pressure in the group of women before the treatment was 125.72

mmHg, after the first sauna session it was 124.11 mmHg, after the second sauna session 122.42 mmHg, and after the third 122.88 mmHg. The systolic blood pressure after the first and second sauna session decreased considerably, yet it increased slightly after the third one. Nevertheless, the final values show a downward tendency in comparison to the initial values.

The comparative analysis of the systolic blood pressure in the group of women after the first, second and third sauna session with its values before the treatment confirms that the most statistically significant decrease of the systolic blood pressure occurred after the second sauna session and the least statistically significant decrease occurred after the first sauna session and the cooling phase (Tab. 6, Fig. 1).

The average diastolic blood pressure in the group of women before the treatment was 77.92 mmHg, after the first sauna session it decreased to 70.81 mmHg, after the second sauna session it dropped further to 60 mmHg, and after the third sauna session it increased slightly to 67.51 mmHg (Tab. 4, Fig. 2).

Having analysed the dynamics of the diastolic blood pressure in the examined women it may be stated that the most statistically significant decrease was observed, like in the case of the systolic blood

<i>Blood pressure and heart rate of women and men</i>							
Variable	Research	Women (N = 100)		Men (N = 73)		Test t-Studenta	
		\bar{x}	s	\bar{x}	s	t	p
		Systolic pressure [mmHg]	0	125,72	16,01	147,56	13,68
1	124,11		15,03	144,18	14,48	-8,81	0,0000
2	122,42		15,29	141,14	14,13	-8,21	0,0000
3	122,88		13,76	139,08	13,20	-7,78	0,0000
Diastolic pressure [mmHg]	0	77,92	9,94	79,88	9,52	-1,30	0,1948
	1	70,81	12,08	71,49	10,77	-0,38	0,7012
	2	67,00	10,64	68,59	11,42	-0,94	0,3481
	3	67,51	9,40	71,18	9,73	-2,50	0,0135
Pulse [heartbeats per minute]	0	80,82	12,48	72,96	13,42	3,96	0,0001
	1	82,38	14,95	76,32	15,19	2,62	0,0097
	2	82,45	15,14	77,00	16,18	2,27	0,0244
	3	82,92	16,77	75,73	15,94	2,85	0,0050

Table 5

Avg. differences between blood pressure and heart rate of women and men in different phases

Variable	Research stage	Women (N = 100)		Men (N = 73)		Student's t-Test	
		\bar{x}	s	\bar{x}	s	t	P
Systolic pressure [mmHg]	0 – 1	1,61	16,66	3,38	14,24	-0,73	0,4636
	0 – 2	3,30	17,32	6,42	14,19	-1,26	0,2085
	0 – 3	2,84	15,58	8,48	14,54	-2,42	0,0167
	1 – 2	1,69	14,62	3,04	11,92	-0,65	0,5179
	1 – 3	1,23	12,90	5,10	11,36	-2,05	0,0423
	2 – 3	-0,46	10,96	2,05	10,51	-1,52	0,1311
Diastolic pressure [mmHg]	0 – 1	7,11	10,60	8,38	10,71	-0,78	0,4381
	0 – 2	10,92	9,87	11,29	11,77	-0,22	0,8238
	0 – 3	10,41	8,99	8,70	9,43	1,21	0,2275
	1 – 2	3,81	10,31	2,90	9,56	0,59	0,5571
	1 – 3	3,30	10,55	0,32	10,36	1,85	0,0657
	2 – 3	-0,51	8,06	-2,59	10,53	1,47	0,1432
Pulse [heartbeats per minute]	0 – 1	-1,56	11,89	-3,36	9,84	1,05	0,2934
	0 – 2	-1,63	14,49	-4,04	12,79	1,13	0,2580
	0 – 3	-2,10	16,99	-2,77	13,20	0,28	0,7802
	1 – 2	-0,07	11,99	-0,68	10,41	0,35	0,7254
	1 – 3	-0,54	13,88	0,59	10,26	-0,59	0,5577
	2 – 3	-0,47	10,49	1,27	10,91	-1,06	0,2896

pressure, after the second sauna session and the cooling phase (Fig. 1, 2).

The mean heart rate prior to the treatment in the examined women was 80.82 beats per minute. The heart rate analysis in the group of women subjected to overheating in the sauna room revealed a distinct increase of the pulse to 82.38 beats per minute after the first sauna session, a slight increase to 82.45 beats per minute after the second one, and to 82.92 beats per minute after the third one (Tab. 4). Therefore the following conclusion may be drawn: the sauna treatment results in a permanent increase of heart rate, even though it remains within the physiological norm (Tab. 3). The highest pulse values in relation to the state before the treatment were observed after the third sauna session. Therefore it may be stated that the sauna is for the body a form of physical

effort resulting in increased heart rate.

A significant difference in the average systolic blood pressure was observed in the examined men. Before the treatment, the systolic blood pressure was 147.56 mmHg, after the first, second and third visit to the sauna it gradually decreased to 144.18 mmHg, 141.14 mmHg and 139.08 mmHg respectively (Tab. 6, Fig. 1). The research results show a systematic decrease of the systolic blood pressure in the examined men after the first, second and third sauna session in comparison to initial values. Scientific publications confirm that sauna decreases the arterial blood pressure both in healthy individuals and in people suffering from arterial hypertension (Brzostek et al. 2007).

The diastolic blood pressure in the group of men showed a slightly different tendency. Before the

Table 6

*The evaluation of variations in blood pressure and heart rate of women and men before sauna treatment and between following treatments – variation analysis and test LSD**

Variable	ANOVA			Comparison post-hoc test LSD, value p compared researches					
	Men	F	p	0 – 1	0 – 2	0 – 3	1 – 2	1 – 3	2 – 3
Systolic pressure	12,01	0,0000	0,0259	0,0000	0,0000	0,0000	0,0451	0,0009	0,1747
Diastolic pressure	32,33	0,0000	0,0000	0,0000	0,0000	0,0000	0,0181	0,7964	0,0349
Pulse	3,59	0,0146	0,0119	0,0025	0,0377	0,6053	0,6567	0,6567	0,3368
Women									
Systolic pressure	1,98	0,1171	0,2786	0,0268	0,0565	0,2555	0,4076	0,7567	
Diastolic pressure	53,01	0,0000	0,0000	0,0000	0,0000	0,0000	0,0001	0,0008	0,6022
Pulse	0,92	0,4305	0,2473	0,2268	0,1197	0,9586	0,6885	0,7272	

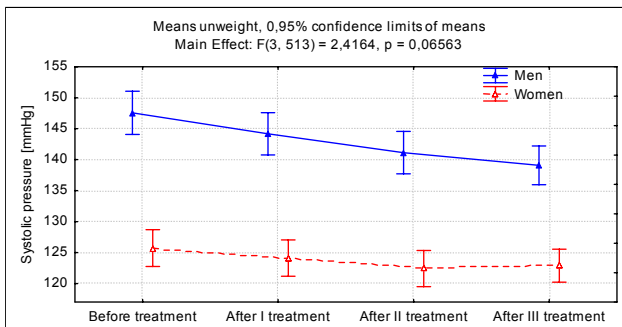


Figure 1

The characteristics of systolic pressure in the group of men and women before sauna treatment and after the following treatments and cool down

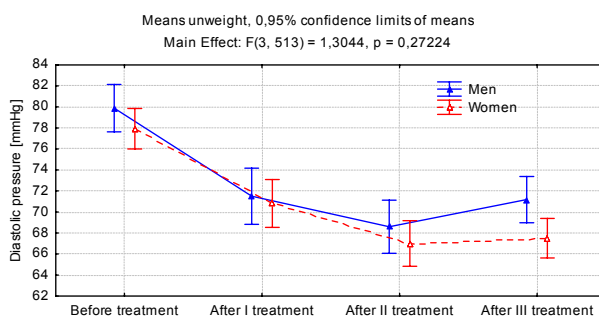


Figure 2

The characteristics of diastolic pressure in the group of men and women before sauna treatment and after the following treatments and cool down

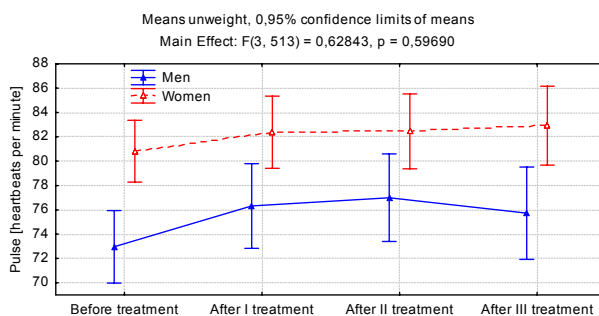


Figure 3

The characteristics of pulse in the group of men and women before sauna treatment and after the following treatments and cool down

sauna treatment it was 79.88 mmHg, after the first and second sauna session it decreased to 71.49 mmHg and 68.59 mmHg respectively, however, after the third sauna session it increased to 71.18 mmHg (Fig. 2). The increase of the diastolic blood pressure after the third sauna treatment may indicate that the adaptation processes to overheating were activated.

The reaction of the heart to overheating in the examined men is also worth mentioning. Before entering the sauna, the pulse was 72.96 beats per minute, it increased to 76.32 and 77 beats per minute after the first and second session, while after the third sauna session it dropped to 75.73 beats per minute. The decrease of the pulse in the examined men after the third sauna session may suggest an improvement of the thermoregulatory and adaptation mechanisms of the circulatory system. However, the way the Finnish sauna affects the body may be compared with the effects of physical exercise what is manifested by increased heart rate (Fig. 3).

Discussion

High temperature in the sauna room increases the temperature of the body and activates the thermoregulatory mechanisms this way boosting the cutaneous blood flow and sweat secretion (Pilch et al. 1994). It happens because the body absorbs from the environment more heat than it is able to give off. Consequently the temperature of both the skin and the body increases (up to 37.6 – 40°C). The changes in subjects who repeatedly used the sauna were more significant after the first exposure to the heat in the sauna in comparison with the last measurement which shows improvement of the thermoregulatory mechanisms resulting from a series of sauna sessions (Brzostek et al. 2007).

The research results show that the systolic blood pressure in the examined women after decreasing at first increased slightly which may indicate adjusting to the sauna conditions. As for the diastolic blood pressure, a similar tendency was noticed in both the examined men and women. After the first and second sauna session the diastolic blood pressure decreased, yet after the third sauna session it increased. The changes of the heart rate in the group of women exposed to overheating may also indicate that the circulatory system adapted to the new conditions as the highest increase of the heart rate occurred after the very first sauna session. After the subsequent sessions only a slight increase was observed.

The systolic blood pressure in the examined men decreased considerably from the statistical point of view under the influence of alternating hot and cold effects of the sauna sessions, yet after the last sauna session the decrease was minor which may also suggest adaptation to the environmental conditions. A less significant increase of the heart rate after the last sauna session may also indicate beneficial adaptive

changes in the cardiovascular system in the examined men and women after the series of sauna sessions.

It is believed that the Finnish sauna has a stress-inducing effect. Under the influence of alternating hot and cold stimuli the secretion of the adrenocorticotrophic hormone by the pituitary gland as well as the secretion of cortisol and catecholamines by the adrenal glands increases. Regular sauna sessions stimulate the glands that secrete the abovementioned hormones, especially the adrenal cortex, whose activity improves significantly (Groves 1987). It was also observed that after the regular sauna sessions, physical efficiency improved (Kauppinen et al. 1986, Groves 1987) which was also confirmed by the examined.

The authors claim that repeated sauna sessions boost the adaptative capabilities to the changing environmental conditions, help to increase physical efficiency and finally improve one's mental condition (Choraży, Kwaśny 2005).

The research results are similar to those obtained by other researchers and referring to the influence of the sauna on the pulse and arterial blood pressure in people of various levels of physical fitness. The research group consisted of 30 people aged 20–24 who were divided into three groups of not physically fit, moderately fit and very fit subjects. They were subjected to the overheating and cooling phases three times. The results showed a positive effect of the sauna on the heart rate (HR). The findings of this research confirm the interdependence. However, the findings concerning arterial blood pressure were different than the ones obtained by the authors of this research. The systolic and diastolic blood pressure in the moderately fit and not fit individuals did not show significant changes, yet an upward tendency was observed. In this research though, a downward tendency of the systolic and diastolic blood pressure in the group of men and women was noted. The differences may result from the fact that in this research the measurements of the pulse and arterial blood pressure were taken after leaving the sauna room, that is after the overheating and cooling phase, whereas during the other research (Choraży, Kwaśny 2005), these measurements were taken after the heating phase and after the cooling phase separately. It is obvious that these two phases affect the human body differently.

Using the sauna increases energy expenditure. Under the influence of high temperature the heart is

forced to work more intensively in order to pump large amounts of blood to the hypodermic capillary vessels. It was proved that during a sauna session, the human body burns about 300 kcals which is equal to the value needed to run 3–4 km (Tanny 1995). It is presumed that the higher heart rate is a result of the increased blood temperature and the reflexive stimulation of the adrenergic beta receptors of the heart. The increase of the heart rate is conditioned by the time spent in the sauna room, age, gender and physical fitness.

After leaving the sauna the pulse drops gradually which is confirmed by the research results. If the cooling phase takes place in room temperature, the heart rate returns to the initial values in 1–4 hours. Most researchers claim that high humidity in the sauna influences the heart rate only slightly (Brzostek et al. 2007). However, the cooling phase normalises all the processes: the blood vessels contract, the body temperature decreases, the oxygen saturation of the blood rises (Adamczyk-Bujniwicz 2003).

Conclusions

1. It was observed that the heart rate in both men and women under the influence of the sauna treatment increased significantly, the systolic blood pressure substantially decreased, and the diastolic blood pressure did not show essential changes, even though a downward tendency was noticed. Therefore, it may be said that the sauna positively influences the hemodynamics of the pulse and arterial blood pressure.
2. The researchers observed a statistically significant downward tendency of the systolic and diastolic blood pressure and the increased heart rate in the examined subjects, resulting from a series of sauna sessions and cooling.
3. The heart rate changes were more significant in the group of men which may indicate better functioning of the thermoregulatory and adaptive mechanisms of the circulatory system during the overheating and cooling phase.

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