



# The human body's response to the conditions in the sauna

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## Abstract

*Aim:* The aim of this study was to determine the effect of a 15-minute bathing session in a Finnish sauna on changes in systolic and diastolic blood pressure (SBP and DBP, respectively), heart rate (HR), and body mass. The effects of grouping variables (age, sex, BMI, frequency of sauna use, history of sauna use) were taken into account in the analysis. *Materials and Methods:* A total of 60 women (33.6±13.1) and 42 men (33.8±12.5) aged 17 to 79 participated in one 15-minute sauna session (temperature: 90-91°C; relative humidity: 14-16%) in December 2019, in the city of Wrocław, Poland. The participants' body mass, SBP, DBP and HR were measured before and after sauna. Body height was measured only before sauna. *Results:* Sauna induced significant changes in the participants' physiological parameters. Systolic blood pressure decreased ( $p<0.05$ ) in both sexes, in older participants ( $p<0.001$ ) regardless of their BMI, and in participants who had rarely used sauna and had used sauna for a minimum of several years. A significant decrease in DBP ( $p<0.001$ ) and HR values and a significant loss of body fluids ( $p<0.001$ ) was noted in both sexes regardless of age, BMI, frequency and history of sauna use. *Conclusions:* A 15-minute sauna session has a beneficial effect on the circulatory system and can be incorporated into cardiovascular therapies. Regular sauna use is an important factor, and optimal results can be achieved by visiting sauna several times a week.

**Keywords:** thermal stress, blood pressure, heart rate, body mass loss, participants from different age groups

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## INTRODUCTION

One of the first studies investigating the health benefits of sauna was conducted in Finland in the 1960s. Since then, sauna bathing has gained popularity not only in Scandinavia, but also in other West European countries. Sauna bathing has positive health implications for both very young and older users of both sexes [1]. The results of a long-term study conducted in Finland on a group of more than 2000 male participants revealed a considerably lower prevalence of myocardial infarction, coronary heart disease and sudden cardiac arrest among sauna users [2]. Regular and long-term sauna use also lowers the risk of hypertension in middle-aged men [3]. However, recent research has demonstrated an increase in blood pressure and heart rate (HR) in middle-aged individuals attending 25-minute sauna sessions [4]. According to other authors, regular sauna use does not exert a significant influence on systolic (SBP) or diastolic blood pressure (DBP), and it leads to an improvement in the left-ventricular ejection fraction [5]. Sauna bathing promotes immune function and, consequently, increases lymphocyte, leukocyte and monocyte counts [6]. Sauna induces sweating and leads to considerable loss of body fluids, but its influence on changes in body composition remains ambiguous. Gryka et al. [7] did not observe significant changes in body mass, body fat percentage or lean body mass in 16 young and physically active men who participated in 10 sauna sessions over a period of 2-3 weeks. However, four sauna sessions induced a significant decrease in the body mass of 45 sedentary young men [8]. In another study, sauna bathing led to a greater loss of bodily fluids in heavier men than in leaner participants [9]. The optimal duration of sauna treatment and the number of sauna sessions for achieving the desired health outcomes have not been defined in the literature. A positive correlation was noted between long-term, regular sauna use and a reduced risk of fatal coronary heart disease and fatal cardiovascular disease, but positive cardiovascular changes were also observed in middle-aged men after a single sauna session [10]. Therefore, the aim of this study was to determine the effects of a 15-minute session in a Finnish sauna on changes in SBP, DBP, HR and body mass (loss of bodily fluids) in individuals characterized by different age, sex, BMI, frequency and history of sauna use.

## MATERIALS AND METHODS

### *Participants*

Data for the study were collected from a sports club spa in Wrocław in December 2019. A total of 60 women aged 17 to 71 ( $33.6 \pm 13.1$ ) and 42 men aged 22 to 79 ( $33.8 \pm 12.5$ ) were evaluated. The participants were divided into two age groups based on the median age: younger (younger than 34) and older (34 and older) ( Table 1).

### *Ethical approval*

The study was conducted upon the prior consent of the Ethics Committee of the University of Warmia and Mazury in Olsztyn (No. 39/2011), Poland. The study was performed on volunteers who signed an informed consent statement.

### *Instruments and procedures*

The participants received comprehensive information about sauna rules before the study. They were instructed to drink at least one liter (L) of water on the day before the test and 0.5 L of water 2 hours before the test.

Body height was measured to the nearest 1 mm with a stadiometer, and nude body mass was measured to the nearest 0.1 kg with a calibrated WB-150 medical scale (ZPU Tryb Wag, Poland). Blood pressure (BP) and HR were determined with an automatic digital blood pressure monitor (Omron M6 Comfort, Japan). Body mass, SBP, DBP and HR were measured twice, i.e. immediately before sauna and 15 minutes after sauna (temperature: 90-92°C; relative humidity: 14-16%), in a seated position, on the left arm.

Table 1. Types of grouping variables and population in each group

Grouping variables	Type					
	Variable	N	%	Variable	N	%
Age [years]	Younger $\leq$ 33	57	55.9	Older $\geq$ 34	45	44.1
Sex	Women	60	58.8	Men	42	41.2
BMI [kg/m <sup>2</sup> ]	18.5-24.99	70	68.6	$\geq$ 25	32	31.4
Frequency	Frequently	41	40.2	Rarely	61	59.8
History	Long-term	67	65.7	Short-term	35	34.3

The participants were divided into two groups based on their BMI values (according to the WHO classification): persons with normal body mass (BMI of 18.5-24.99 kg/m<sup>2</sup>) and overweight persons (BMI  $\geq$ 25 kg/m<sup>2</sup>). The evaluated individuals were also divided into groups based on the frequency of sauna use: 1) frequently – daily or several times a week, 2) rarely – once a week or less often, as well as the history of sauna use: 1) long-term – several to more than ten years, 2) short-term – up to 1 year or for the first time (Table 1).

### Statistical analysis

Data were processed statistically in the Statistica 13.3 program. Arithmetic means, standard deviation, and the minimum and maximum values were calculated for the evaluated physiological parameters. Changes in SBP, DBP, HR and body mass before and after sauna were determined separately for each grouping variable in Student's t-test.

## RESULTS

**Sex** – A significant decrease in SBP and, in particular, in DBP was noted in male and female subjects after a 15-minute sauna session (SBP: M - 6.8 and W - 3.4 mmHg; DBP: M - 6.9 and W - 5.9 mmHg) (Table 2). The average HR (HR<sub>avg</sub>) increased highly significantly in both sexes, in particular in women (M - 9 bpm; W - 14.5 bpm). The observed differences in body mass before and after sauna resulted from the loss of body fluids. Body mass loss was significant and comparable in both sexes, and it was determined at 0.36 kg in men (4.55 g/1 kg body mass) and 0.23 kg in women (3.64 g/1 kg body mass) on average. The differences between male and female participants were not significant ( $p=0.231$ ).

**Age** – SBP values did not change significantly ( $p = 0.103$ ) in younger participants (below 34 years of age), but a significant decrease ( $p<0.001$ ) of 7.6 mmHg was noted in older subjects (Table 3). Diastolic blood pressure decreased significantly ( $p<0.001$ ) in both age groups (by 6.2 mmHg). A significant increase in resting HR was observed during sauna in both younger and older bathers (by 13.1 and 10.7 bpm, respectively). Body fluid loss was significant ( $p<0.001$ ) in both younger and older participants. On average, older bathers were characterized by higher body mass and higher body fluid loss than younger bathers. No significant differences ( $p=0.893$ ) in body fluid loss measured in grams per kilogram of body mass were noted between younger and older individuals. On average, younger participants lost 0.28 kg (4.06 g/1 kg body mass), and older participants lost 0.29 kg (3.96 g/1 kg body mass).

**BMI** – sauna induced a significant decrease in the BMI of participants with normal body mass (N), and an even greater decrease in the BMI of overweight subjects (O) (N - 3.1 mmHg, O - 8.5 mmHg) (Table 4). A significant decrease in DBP was noted in both groups (N - 6.2 mmHg, O - 6.4 mmHg). Heart rate increased highly significantly in both groups (N - 12.6 bpm, O - 11.1 bpm). Body mass (body fluid) loss was identical in overweight subjects and in participants with normal body mass. The observed differences were significant in both cases. Individuals with normal body mass lost 0.27 kg (4.13 g/1 kg body mass) on average. Overweight subjects lost more body fluids than lean participants (0.33 kg), but the corresponding loss per kilogram of body mass was lower (3.76 g/1 kg body mass). However, the observed difference was not significant ( $p=0.647$ ).

Table 2. Descriptive statistics of the parameters evaluated before and after sauna in men (N=42) and women (N=60)

Parameter	Sex	Before sauna			After sauna			Differences	
		Mean	SD	min-max	Mean	SD	min-max	t	p
SBP [mmHg]	M	138.9	14.4	115-176	132.1	14.8	98-172	3.21	0.003
	W	118.9	11.1	102-147	115.5	11.0	93-141	2.16	0.035
DBP [mmHg]	M	87.8	8.9	71-105	80.9	11.2	58-106	3.92	<0.001
	W	78.3	8.2	58-96	72.4	7.9	59-94	4.86	<0.001
HR [bpm]	M	74.9	17.5	48-116	83.9	20.4	50-135	3.57	<0.001
	W	78.9	13.4	62-130	93.4	16.6	66-139	7.16	<0.001
BM [kg]	M	80.9	14.3	54.95-117.0	80.6	14.3	54.8-116.3	7.29	<0.001
	W	64.2	12.1	43.5-94.6	64.0	12.1	43.4-94.3	8.52	<0.001

M – men, W - women, SBP - systolic blood pressure, DBP - diastolic blood pressure, HR - heart rate, BM - body mass

Table 3. Descriptive statistics of the parameters evaluated before and after sauna in younger (Y, N=57) and older (O, N=45) participants.

Parameter	Age	Before sauna			After sauna			Differences	
		Mean	SD	min-max	Mean	SD	min-max	t	p
SBP [mmHg]	Y	126.9	16.0	102-176	124.3	15.3	99-164	1.66	ns
	O	127.5	16.0	102-161	119.9	14.7	93-172	3.71	<0.001
DBP [mmHg]	Y	81.1	8.4	59-99	74.9	9.7	58-105	4.76	<0.001
	O	83.5	10.9	58-105	77.3	10.8	60-106	4.00	<0.001
HR [bpm]	Y	78.7	15.3	49-126	92.0	20.7	50-139	5.94	<0.001
	O	75.5	15.2	48-130	86.2	15.6	62-128	4.85	<0.001
BM [kg]	Y	69.0	14.6	43.5-117.0	68.7	14.5	43.4-116.3	7.90	<0.001
	O	73.8	16.1	46.0-115.7	73.5	16.1	45.9-115.3	7.23	<0.001

Y – younger, O – older, SBP - systolic blood pressure, DBP - diastolic blood pressure, HR - heart rate, BM - body mass

Table 4. Descriptive statistics of the parameters evaluated before and after sauna in participants with normal body mass (N, N=70) and overweight subjects (O, N=32)

Parameter	BMI	Before sauna			After sauna			Differences	
		Mean	SD	min-max	Mean	SD	min-max	t	p
SBP [mmHg]	N	122.6	13.8	102-163	119.5	15.3	93-164	2.39	0.020
	O	137.0	16.1	109-176	128.5	12.9	98-172	3.00	0.005
DBP mmHg]	N	81.4	9.0	59-104	75.2	10.1	58-105	5.36	<0.001
	O	83.9	10.9	58-105	77.5	10.5	58-106	3.20	0.003
HR [bpm]	N	78.7	15.2	49-130	91.3	19.6	50-139	6.44	<0.001
	O	74.2	15.1	48-113	85.3	16.4	60-128	4.12	<0.001
BM [kg]	N	63.6	9.6	43.5-94.2	63.3	9.5	43.4-94.0	8.43	<0.001
	O	87.6	12.6	66.8-117.0	87.3	12.5	66.6-116.3	6.73	<0.001

N – normal, O - overweight, SBP - systolic blood pressure, DBP - diastolic blood pressure, HR -heart rate, BM - body mass

*Frequency of sauna use* – significant changes in SBP values were observed in occasional sauna-goers, but not in participants who used the sauna regularly (Table 5). A significant decrease in DBP was noted in both frequent and infrequent sauna users. Heart rate increased significantly after sauna in both groups. The average body mass loss was determined at 0.27 kg (3.84 g/1 kg body mass) in occasional sauna users, and it was statistically significant. Frequent sauna bathers lost 0.31 kg of body mass (4.28 g/1 kg body mass) on average. The loss of body fluids did not differ significantly ( $p=0.564$ ) between the compared groups.

Table 5. Descriptive statistics of the parameters evaluated before and after sauna in participants who used the sauna frequently (F, N=41) and rarely (R, N=61).

Parameter	Frequency	Before sauna			After sauna			Differences	
		Mean	SD	min-max	Mean	SD	min-max	t	p
SBP [mmHg]	F	127.6	17.7	102-176	123.5	13.8	101-164	1.81	ns
	R	126.8	14.8	102-163	121.6	15.9	93-172	3.50	<0.001
DBP [mmHg]	F	82.6	9.9	58-104	75.1	8.5	60-105	5.28	<0.001
	R	81.9	9.5	59-105	76.4	11.3	58-106	3.94	<0.001
HR [bpm]	F	78.7	15.3	54-116	91.8	18.3	62-139	6.58	<0.001
	R	76.3	15.3	48-130	87.9	19.1	50-139	5.02	<0.001
BM [kg]	F	70.3	14.1	46.0-117.0	70.0	14.1	45.9-116.3	6.56	<0.001
	R	71.6	16.3	43.5-115.7	71.3	16.2	43.4-115.3	8.59	<0.001

F - frequently, R- rarely, SBP - systolic blood pressure, DBP - diastolic blood pressure, HR - heart rate, BM - body mass

Table 6. Descriptive statistics of the parameters evaluated before and after sauna in long-term (L, N=67) and short-term (S, N=35) sauna users

Parameter	History	Before sauna			After sauna			Differences	
		Mean	SD	min-max	Mean	SD	min-max	t	p
SBP [mmHg]	L	127.3	16.5	102-176	122.0	15.4	93-172	3.25	0.002
	S	126.8	15.0	102-163	123.0	14.7	99-164	1.88	ns
DBP [mmHg]	L	82.3	10.2	58-104	75.0	9.3	58-106	5.72	<0.001
	S	81.9	8.7	69-105	77.8	11.8	59-105	2.70	0.011
HR [bpm]	L	74.3	12.5	48-116	87.6	17.5	50-135	7.61	<0.001
	S	83.1	18.3	49-130	92.9	20.9	60-139	3.11	0.004
BM [kg]	L	72.1	16.1	43.5-117.0	71.8	16.0	43.4-116.3	8.98	<0.001
	S	69.2	14.1	48.6-115.7	69.0	14.0	48.5-115.3	6.14	<0.001

L - long-term users, S - short-term users, SBP - systolic blood pressure, DBP - diastolic blood pressure, HR - heart rate, BM - body mass

*History of sauna use* - a significant decrease in SBP (by 5.3 mmHg) was noted in long-term sauna users. Sauna-induced changes in SBP were not significant in participants who had visited the sauna for less than one year (Table 6). A significant decrease in DBP was observed in both long-term (more than one year) and short-term sauna users (by 7.3 and 4.1 mmHg, respectively). Heart rate increased significantly, in particular in habitual sauna users (L - 13.3 and S - 9.8 bpm). Body fluid loss during a 15-minute sauna session was determined at 0.31 kg (4.34 g/1 kg body mass) in long-term sauna users and at 0.23 kg (3.38 g/1 kg body mass) in short-term users. The observed differences were significant in both cases. No significant differences ( $p=0.222$ ) in body fluid loss per kg of body mass were noted between habitual and occasional sauna-goers.

## DISCUSSION

The aim of this study was to evaluate the effects of a 15-minute session in a Finnish sauna on the physiological parameters of men and women aged 17-79. The experimental design is consistent with the findings of Kauppinen [11] who observed that physiological processes reach peak levels after approximately 15 minutes of sauna bathing. A literature review conducted by Hussain and Cohen [12] demonstrated that exposure to thermal stress increases cardiac output and decreases peripheral vascular resistance. Sauna also decreases SBP and DBP [13]. Hussain and Cohen [12] analyzed the effects of Finnish sauna and infrared sauna where bathers were exposed to heat for 5-30 minutes during each session. In the current study, a significant decrease in DBP was noted regardless of the participants' age, sex or history of sauna use. Similar observations were made by Heinonen and Laukkanen [14] in a review of Finnish sauna users. They reported that even a single, short session in the Finnish sauna decreased SBP and DBP values, and that this trend was more pronounced in regular sauna users. A significant increase in SBP and DBP values was observed in young men exposed to

repeated thermal stress (90°C) during four 12-minute sauna sessions [8]. The described sauna conditions were extreme in comparison with those applied in the current study.

Heart rate values increased significantly after sauna, and similar observations were made by other authors [15, 16]. The mean HR values after sauna were not very high (approximately 92 bpm) due to the relatively short duration of the sauna session. Based on the scale proposed by Podstawski et al. [8], the HR values noted in this study were within the easy effort range, i.e. below 101 bpm. In young people who regularly use the sauna, HR increases to around 100-110 bpm, and it can exceed 140-150 bpm with a rise in ambient temperature [17, 18, 19]. An increase in HR to around 120 bpm is regarded as a beneficial adaptive response, whereas an increase in excess of 140 bpm is asserted to have adverse consequences because it is associated with higher cardiac demand and diastole shortening [20]. Therefore, it can be assumed that a 15-minute stay in the sauna at a temperature of 90°C was safe even for the oldest participants (even 79-year-olds who participated in the present study).

The body mass loss observed in this study was similar to that reported by Podstawski et al. [21]. In the cited study, young women and men who attended two 10-minute sessions in a Finnish sauna lost 0.37 kg and 0.5 kg of body mass, respectively. In the current study, sauna induced greater body mass loss in overweight than in lean participants, which corroborates the previous findings of Podstawski. Prolonged stay in the sauna and higher temperature intensify sweating and body mass loss (up to 1.2 kg), in particular in overweight and obese subjects. However, the present study was not conducted under extreme conditions that could lead to dehydration and electrolyte imbalance [22].

## CONCLUSIONS

The results of this study indicate that a 15-minute session in a Finnish sauna delivers physiological effects that are beneficial to human health. Both SBP and DBP decreased in female and male participants, regardless of their BMI or frequency of sauna bathing. An increase in HR was observed in all subjects, regardless of their age, sex or history of sauna use. The present findings also demonstrate that sauna bathing promotes the loss of body fluids, thus decreasing body mass.

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