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Original Research

Effects of Air-Ions on Human Circulatory Indicators

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Abstract

Men and women of different ages were submitted to the activity of negative or positive air-ions several hours a day for from several to more than a dozen days. Shifts in their systolic/diastolic pressures and pulse were determined in the course of these experiments.

The tests have shown a statistically significant influence of the ionized particles, above all on blood pressure. Exposing humans with proper circulatory indicators six hours a day for more than a dozen days to negative air-ions in concentrations of 10,000 ions/cm^3 results in a 5% drop in systolic pressure and around 2% drop in diastolic pressure, but has no influence on the pulse. This effect works until both pressures reach a stable level, which probably can be considered optimal for a given person. However, exposing people to positive air-ions in concentrations of 25,000 ions/cm^3 results in destabilization of the circulatory indicators.

Keywords: air-ions, systolic pressure, diastolic pressure, pulse

Introductions

Large-scale research into the influence of air-ions (ionized particles of air) has been conducted for several dozen years. Detailed monographs have been published, which contain lists of reference studies concerning exclusively this topic and quote the results obtained by particular scientists [1, 2]. Sadly, this issue still raises much controversy as even the authors of the two mentioned monographs [1, 2] admit that many of the experiments described therein were conducted without observing basic scientific research criteria.

This was the case for different reasons. One of them was the fact that the content of ionized particles in the air is so small (a couple of hundred per 1 cm^3 in natural background and a couple of million in 1 cm^3 when strong electric ionizers are used, in comparison with the total of $2.6 \cdot 10^{19}$ of all particles present in 1 cm^3 air), that advanced gauges assembled from high-class electronic components are necessary for credible detection. Such equipment was not available until the late 1970s. Therefore, research conducted before that time cannot be considered reliable.

Another problem is more complex. It results from the fact that most scholars involved in the issue of the effect of air-ions on people believe that these particles affect above all the psychophysical features, which are usually verified insufficiently or even not verified at all [1, 3-10].

In consequence to these two problems, many outcomes of air-ion research often appeared to be contradictory, which led many scientists to believe that ionized particles do not affect living organisms at all and that the effects observed during the air-ion exposure tests are triggered by

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Table 1. The norms* of small air-ion concentrations (n).

Ionization level	n^- (1/cm^3)	n^+ (1/cm^3)
Minimal, required	600	400
Optimal	3,000-5,000	1,500-3,000
Maximum, admissible	50,000	50,000

*Standart Comecon No. 790-77; (PN-80/Z-08052).

some different factor (e.g. that they are caused by the ozone discharged by the electric ionizers [1, 2]).

In the course of our research, the mentioned problems needed to be considered and the experiments had to be devised in such way that the occurrence of possible biological effects could be beyond doubt deemed air-ion-derived.

These requirements were successfully met as the measurements of air-ion parameters were taken with the use of very sensitive gauges capable of recording ionized particles from the level of 20 ions/cm^3, built by the Institute of Nuclear Physics in Krakow (IFJ). Also, the ionizers used for the test (also built by IFJ) were of high stability. Limiting the applied voltage to the level that allowed discharging air-ions at the maximum concentration of 7.5 million ions/cm^3 guaranteed that no ozone would be discharged in the process [11].

Our research into the effects of air-ions on living organisms was preceded by a series of measurements of concentrations and mobility (μ) of these particles (μ defined as the rate of the additional velocity component, independent of the thermal velocities, reached by air-ions in the electrical field to the intensity of this field) in a broadly defined atmospheric background [12-15], and compartments of different kind [11, 16-18]. These tests were conducted, among others, to check if the concentrations of the ionized particles (n) in human environment may reach levels exceeding the established standards. These standards, listed in Table 1 below, were first established in 1980 in the former USSR (sanitation regulations No. 21-52-50) and were then introduced in all former Comecon countries as Comecon standard no. 790-77; PN-80/Z-08052. Raising much controversy these days [17], formally they are still in power (also quoted in scientific works published beyond the borders of the former Eastern Block).

The standards listed in Table 1 refer exclusively to the so-called small air-ions, as only these may induce significant biological effects in living organisms according to the currently acknowledged theorems. The criterion used to differentiate ionized particles into small and big is related to their mobility value (μ). The dividing border is established quite freely, but most scholars assume that the mobility of small air-ions is $\mu > 0.01$ cm^2/(V×s), and in case of the big air-ions: $\mu < 0.01$ cm^2/(V×s) [1, 2, 8, 9, 19].

One of the conclusions of the research was that, extreme cases aside, the density of air-ions does not exceed the border values listed in Table 1. Yet there are exceptions (an observatory in the French Pyrenees [20], rooms housing cobalt therapy units [18], vessel cabins [21]). However, they are rare, which has led to the general conclusion resulting from the initial research into the air-ions parameters that at the natural atmospheric background and also indoors where artificial sources of air-ionization are not applied, the concentrations of air-ions are within the framework specified by the standards in power.

However, the situation changes when ionizers are used. Experiments we conducted proved that, e.g., exposing lymphocytes (*in vitro*) to the activity of air-ions of $n^\pm$ values exceeding 80,000 ions/cm^3, resulted in metaphase atrophy [22]. Experiments on microorganisms, on the other hand, showed that, depending on the concentrations, the effects of air-ions may be of a different kind. For example, placing a culture of *Staphylococcus epidermidis* in the air concentrated with air-ions of n^- = 2 million ions/cm^3 did not result in any significant difference to the development of these bacteria compared to the reference culture placed in a neutral environment. At n^- = 4 million ions/cm^3 the culture multiplied in volume several times. However, at n^- = 7.5 million ions/cm^3 a reverse effect occurred – the bacteria diminished in number several times in comparison to the reference culture [11].

Just as in the case of tests on natural atmosphere and air ionization in experimental compartments, the tests on simple organisms (*Candida albicans*, *Escherichia coli*, and *Acanthamoeba castellanii* were also tested) were of preliminary character before starting research into the effects of ionized air on people. In principle, they were conducted to learn what air-ion concentration levels will trigger biological effects in different organisms. These levels occurred to be different depending on specific living structures, yet relatively high – from one to several times higher than typical of natural background. Additionally, the experiments showed that the typically publicized theorems claiming that negative air-ions have generally a positive effect on living organisms while the positive air-ions have negative effects are invalid – the tests on showed that the biological effects additionally depend on the concentration of air-ions.

The gathered data were used to design experiments on people. Among others, research into the effects of positive and negative air-ions on students performing physical exercise was conducted. The conducted tests showed a high levels of credibility (practically 100%) that positive air-ions (with concentrations of 7.5 million ions/cm^3) exposed to men performing a 10-minutes exercise test, drastically shorten the time of shift from aerobic to anaerobic metabolism, and lower the oxygen consumption and carbon dioxide discharge. Similar effects, yet of lower intensity, occurred in identical experiments when negative air-ions were introduced to the respiratory system [23].

These experiments confirmed that accordingly high concentrations of ionized particles are able to trigger specific physiological effects in people. However, a question whether air ions of much lower concentrations can trigger any biological effects in people when exposed for much longer period has remained unanswered.

To check if this is possible, it was decided to conduct a series of experiments on people exposed to the atmosphere concentrated with air-ions up to the level of several dozen ions/cm^3 for an extended period of time (at least 5 hours a day for no less than 10 days). During that period, the people subjected to the experiments were checked for their circulatory indicators.

There were several reasons for selecting circulatory indicators as a reference to show the possible effect of air-ions on people. One of them was that the measurements of systolic pressure, diastolic pressure and pulse give much more verifiable results than tests on changes of human psycho-physical features [24]. Another reason for selecting these indicators was that such experiments had been already conducted by several scientists and gave contradictory results. Therefore, there was a requirement to explain why some of them claimed that positive air-ions increase arterial pressure while others suggested the contrary – that it is reduced by air-ions [2, 25, 26]. Offering an explanation to this issue was also important as the contradictory measurement results obtained in air-ions experiments are used by some scientists who undermine the possibility that these particles affect living organisms to offer theorems that changes in the level of air ionization are not relevant to living organisms, and in particular to people.

However, the choice of circulatory indicators for analysis of the influence of air-ions on people was connected with a specific problem – for many years nobody made any attempt to resolve this issue, which makes it impossible to compare the obtained results. This is most probably caused by the arduousness of the task, and the time it takes to conduct the examinations. Generally speaking, however, the influence of different factors on human blood pressure and pulse has been extensively described in scientific literature. This offered an opportunity to verify the obtained results against possible interference which could affect the air-ion experiments [27-29].

Material and Methods

Research into the changes of human circulatory indicators encounter a fundamental hindrance, namely the fact that human arterial pressure and pulse are affected by many versatile factors, some of which would surely occur during the research conducted over an extensive period of time and would interfere with the analysis of the effects of one specific factor. This imposed introducing rigorous restrictions that needed to be observed during the series of experiments. These restrictions involved both the selection of persons to be tested and their behavior during the tests.

In the preliminary phase of experiments on the effects of ionized particles on circulatory indicators, around 50 persons between 24-48 years old were submitted to the tests. They all met the following criteria:

– During the tests all of them were entirely healthy and had never suffered from any circulation-connected ailments.
– They all were non-smokers for at least four years, none of them was addicted to drugs or alcohol.
– All of them performed non-stressful schematic office work in places free from nicotine smoke and excessive noise.
– During their work, when they were not submitted to the activity of air-ions and no other factors which might significantly affect their arterial pressure, their circulatory parameters changed in a minimal way. In practice, this criterion was fulfilled by excluding persons who in the preliminary phase of the experiments had irregular, permanently exceeding by more than 5% in a module changes from the original levels of pressure without any external factors which could justify such shifts. The systolic pressure was selected as a criterion because it exhibits most regular changes.
– The time of their work was regulated (in hours: 7-8 to 15-16) with the condition that any possible absence from the workplace where the ionizers were installed did not exceed 1 hour.
– All of them started their work not being exceedingly tired or stressed.
– At work, none of them drank caffeine-containing beverages or used medication or any other substances that might affect circulatory indicators.
– None of them used a computer in a permanent way. Computer use, if it occurred, was occasional and did not last longer than 0.5 hours a day.

If any of the listed conditions was not fulfilled, the test results obtained on a given day were not taken into consideration in further analysis.

The execution of the tests consisted of placing a set of ionizers in the room above the workplace. The capacity of the ionizers and distances between them were adjusted in such a way that even when the position of the head of the tested person changed, it stayed within the range of air-ions of concentrations 10,000 ions/cm^3 (in the case of positive ions – even higher, which is described below), with tolerance ±2,000 ions/cm^3 (it was usually impossible to adjust the concentration more accurately). After two hours from work start (a period approximately deemed necessary for a person to fully adapt to their work place) the pulse and systolic and diastolic pressures of the tested person were measured (with the use of a Japanese electronic blood pressure meter – model MF-39).

The experiment was continued only if the tested person had systolic pressure within the range 120-150 mm Hg, diastolic 75-90 mm Hg, and pulse (HR) within the range 70-90 beats per minute. After confirming that these criteria were met, the ionizers were switched on.

To avoid the factor of suggestion, none of the tested persons was informed about the charge of air-ions emitted on a given day or that they were emitted at all (furthermore, most of the tested persons were not aware of any theorems on differences between the effects of positive and negative ions).

Another measurement of circulatory parameters was taken at least once:

– In such case, approximately half an hour before finishing work. When possible, the changes in pressure and pulse of particular persons were measured more often, sometimes every two hours. In extreme cases, (presented here in Fig. 1, below), the measurements were taken every hour and sometimes even every half hour.

The recorded results were converted into percentage values of shifts in particular indicators from the values measured in the morning hours. Exposing a given person to the activity of air-ions of the same charge always lasted for at least three consecutive days. Breaks between experiment cycles were not longer than two days. The results obtained this way were subjected to final analyses only if they covered data from at least 20 days of measurements for a given person – 10 for positive and 10 for negative air-ions.

Due to the relatively rigorous criteria imposed on the experimental conditions, full sets of data could be obtained only for 18 persons (10 men and 8 women – further analyses did not show any statistically significant differences between male and female participants) out of the group of 50 who were subjected to the tests in the preliminary phase. However, the preliminary measurements, conducted on a three times bigger group of people, gave the conclusion that shifts of circulatory indicators of particular persons triggered by the activity of air-ions of a given charge tend not to stabilize until 2 days after the beginning of the experiments. It is difficult to decide whether this fact results from some physiological reasons or exclusively psychological – people need to adapt themselves to the new situation connected with experiment participation. Observing the inconsistency of shifts in circulatory parameters typical for most tested persons during the first two days of experiments is important as it could explain the different effects of air-ion influence on people indicated by several scientists. Considering the above, in order to eliminate this effect, only data obtained not earlier than on the third day of the experiment were taken into account to prepare the results presented here.

Results

The preliminary tests conducted on the initial group of approximately 50 persons not only gave the previously-mentioned conclusion that the measurements of human circulatory indicators should be recorded from the third day of exposing them to air-ion activity, but also allowed us to determine the critical level of air-ion concentration that triggers shifts in these indicators in effect of long-lasting exposure.

The initial tests with both positive and negative air-ions of concentrations of approx. 5,000 ions/cm^3 showed no statistically significant biological effect among people subjected to such experiments. In the case of negative air-ions, regular, consistently directed shifts in blood pressure and pulse started to occur when the air-ion concentration level was increased to 10,000 ions/cm^3.

An exemplary full set of results for one of the 18 persons who were submitted to the entire cycle of tests (male, 32 years of age) is presented in Table 2. Experiments with this person were conducted for 12 days. Meeting all the criteria listed in the previous chapter, this man was submitted to the activity of negative air-ions of the specified concentration for approximately 6 hours a day (with ±1 h tolerance). To obtain a conclusive confirmation that the observed effects result exclusively from the activity of particles of this charge, the tests on this person were conducted in alteration with exposure to positive air-ions. For comparison purposes, the lower part of Table 2 is filled with the values of the same indicators during the 4 days when this man was not submitted to the activity of air-ions.

The recorded shifts in circulatory indicators presented in Table 2 (and also further in Table 3) are compared against the reference measurements, i.e. measurements taken when the ionizers were switched off.

Despite the fact that the measurement results presented in Table 2 refer only to one man, they are representative enough to use them to draw more general conclusions concerning the effects of negative air-ions of the given concentration on human circulatory parameters.

The most important of them is the slight (on average, above 5%), yet significant (at practically 100% credibility level) drop in systolic pressure after 6 hours of inhaling air-ions, which occurred almost every day in the organism of the tested man. At good significance level ($p < 0.002$ – Student's t-test), the mean drop in diastolic pressure by almost 4% could be observed, yet at relatively high standard divergence value. On the other hand, the shifts in pulse presented in Table 2 leads to the conclusion that negative air-ions of 10,000 ions/cm^3 probably do not affect this indicator. On average, the pulse rate dropped by less than 2%, yet at very high standard divergence level – 2.08, which despite good level of significance ($p < 0.014$) undermines the credibility of the obtained result.

The man, whose test results are presented in Table 2, had his blood pressure measured in a permanent way for several days, i.e. at least every hour and in the first phase of experiments even every 0.5 hour. The outcome of one such measurement (day 6, Table 2) is graphically presented in Fig. 1. As this man had systolic pressure value tendencies similar to other tested people (i.e. a quite quick drop of value of this indicator in the first three, four hours of inhaling

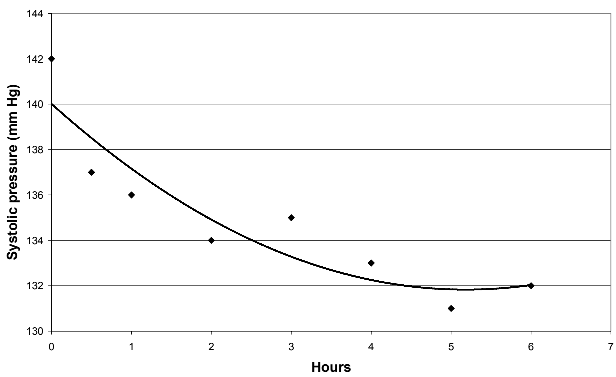

Fig. 1. Changes of the systolic pressure in the function of time measured on a 32-year-old man subjected to the influence of negative air-ions of a concentration of 10,000 ions/cm^3.

Table 2. Changes of circulatory indicators measured on a 32-year-old man subjected to the influence of negative air-ions at a concentration of 10,000 ions/cm³, with reference to test measurements.

	Days	Systolic pressure			Diastolic pressure			HR (pulse)		
		0 h	6 h	Δ x	0 h	6 h	Δ x	0 h	6 h	Δ x
		(mm Hg)		(%)	(mm Hg)		(%)	(1/min)		(%)
Influence of air-ions of $n^- \approx$ 10,000 ions/cm³ for the period of $\approx$ 6 h	1	140	132	-5.71	85	82	-3.53	89	87	-2.25
	2	137	131	-4.38	78	79	1.28	71	70	-1.41
	3	135	129	-4.44	81	80	-1.23	73	73	0.00
	4	142	131	-7.75	82	78	-4.88	86	84	-2.33
	5	132	133	0.76	76	72	5.26	82	80	-2.44
	6	142	132	-7.04	82	75	-8.54	79	80	1.27
	7	144	131	-9.03	87	80	-8.05	75	74	-1.33
	8	137	132	-3.65	84	80	-4.76	75	72	-4.00
	9	138	134	-2.90	78	75	-3.85	84	83	-1.19
	10	140	131	-6.43	79	77	-2.53	88	82	-6.82
	11	139	132	-5.04	75	76	1.33	72	72	0.00
	12	143	134	-6.29	81	77	-4.94	74	73	1.35
	$\overline{x}$	139.08	131.83	–	80.67	77.58	–	79.00	77.50	–
	$\sigma(\overline{x})$	3.50	1.40	–	3.63	2.81	–	6.54	5.76	–
	$\Delta\overline{x}$	–	–	-5.16	–	–	-3.75	–	–	-1.82
	$\sigma(\Delta\overline{x})$	–	–	2.56	–	–	3.11	–	–	2.08
	p <	–	–	$3 \cdot 10^{-5}$	–	–	0.002	–	–	0.014
Without the influence of air-ions	1	138	141	2.17	83	82	-1.20	77	82	15.58
	2	145	142	-2.07	86	81	-5.81	79	77	-2.53
	3	136	137	0.74	76	80	5.26	88	85	-3.41
	4	141	139	-1.42	79	77	-2.53	83	83	0.00
	$\overline{x}$	139.25	139.75	–	81	80	–	81.75	83.50	–
	$\sigma(\overline{x})$	4.65	2.22	–	4.40	2.16	–	5.00	8.90	–
	$\Delta\overline{x}$	–	–	-0.14	–	–	-1.07	–	–	2.41
	$\sigma(\Delta\overline{x})$	–	–	1.96	–	–	4.65	–	–	8.90

Δx – percentage change of the value of an index after 6 h of the influence of air-ions
$\Delta\overline{x}$ – percentage changes of the value of an index after 6 h of the influence of air-ions averaged for all 12 days
σ – standard deviation
p – level of significance (acc. to Student's t-test)

negative air-ions and relative stabilization after this period), his results can be deemed representative. This fact is depicted by the tendency line in the graph (polynomial of degree 2). This trend could also be observed with diastolic pressure values, yet the shifts were smaller and the standard divergence was higher.

The test results and conclusions thereof presented in Table 2 concern one person only. The fact that they may be treated in a more general way can be inferred from the analysis shifts in identical circulatory indicators of all 18 persons participating in the experiment presented in Table 3 (in descending order of mean systolic pressure values), who all were exposed to the activity of negative air-ions for not less than 10 days (permanently or in alteration with emitting positive air-ions). The values presented therein also show that negative air-ions of concentrations approx. 10,000 ions/cm³, inhaled by people for around 6 hours, lower their systolic pressure by approx. 5% at good, or sometimes very good, significance levels p (calculated based on Student's t-test; the p values for median quantities $\Delta\overline{x}$ (%) were calculated with the use of the sign test). The person marked with number 15, whose mean systolic pres-

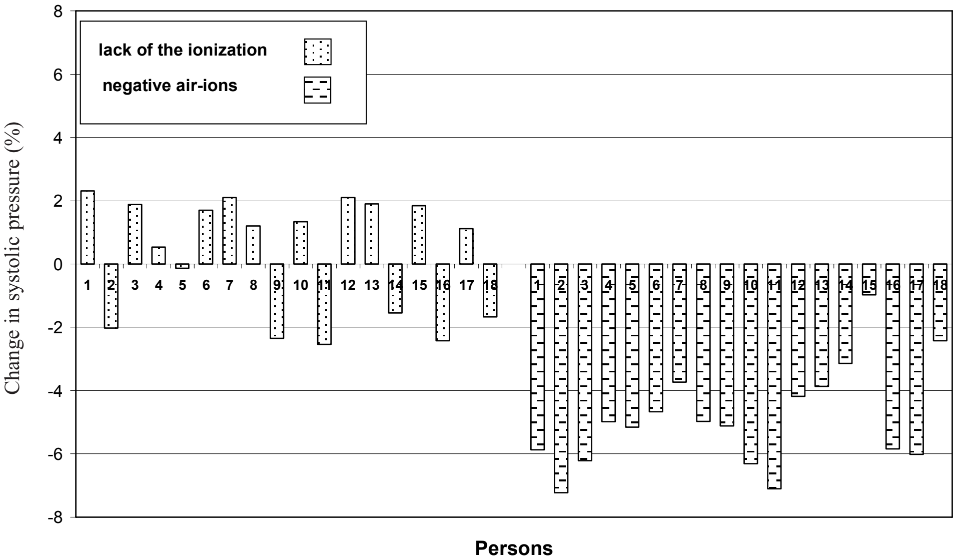

Fig. 2. Average changes of the systolic pressure measured on persons not subjected and subjected to the influence of negative air-ions (10,000 ions/cm^3), with reference to test measurements.

sure drop did not exceed 1% at low significance level equal to 0.21, constitutes an exception here.

As the conducted tests proved, shifts in circulatory indicators do not show statistically significant differences among persons of different sex, weight, or age (at the scope of 24-48 years) exposed to the activity of air-ions (these parameters were not presented in Table 3 or below, in Figs. 2 and 3).

Just as in the case of measurements conducted on one person (Table 2 – in Table 3 they are presented with number 5), the analysis of results presented in Table 3 can lead to the conclusion that negative air-ions of the stated concentration and exposure period lower also the diastolic pressure, yet at around 2× lower rate and with weaker (but still quite good: $p < 0.034$) significance level. Evidently, the air-ions have no effect on human pulse. Among different persons subjected to the experiment, this last indicator either increased or dropped, which ultimately resulted in its mean shift value of only 1.65%, with significance value $p < 0.239$, which makes this result irrelevant.

Both distinctive consistency in shifts of systolic pressure under the influence of negative air-ions (always dropping) and the increase in the mean value shift module are depicted in Fig. 2. It contains percentage systolic pressure shifts from reference tests of all 18 persons subjected to the tests, averaged accordingly from the days when ionizers were switched off and when they emitted negative air-ions of 10,000 ions/cm^3 concentration (the notion of reference tests denotes systolic pressure values measured after two hours from starting the work, directly before the possible initiation of the ionizers).

The percentage mean systolic pressure shifts for all 18 persons, presented in Fig. 2, are as follows: without ionization 0.295% (1.707% if their module values are averaged) and -4.882% when negative air-ions were emitted.

Table 3 shows that an ambiguous yet distinctive effect can be perceived that the higher the initial level of systolic pressure, the greater the drops in its value. This is evident in Fig. 3, where the polynomial tendency line was drawn into the graph created from the values from columns 2 and 3 in Table 3. Possibly, this means that negative air-ions of appropriate concentrations rather optimize the systolic pressure than simply lower it.

This hypothesis is confirmed to a certain degree by an additional experiment conducted on a 28-year-old male, whose arterial pressure was slightly too high (for several years, his mean level of systolic pressure was 155 mm Hg). Contrary to other persons participating in the experiment, he was permanently (during the period of 6 consecutive days) exposed to the activity of exclusively negative air-ions (other persons had their experiment conditions changed – usually after 3-4 days; the polarization of emitted ions was changed – they also often had breaks from exposure between the consecutive days of experiments).

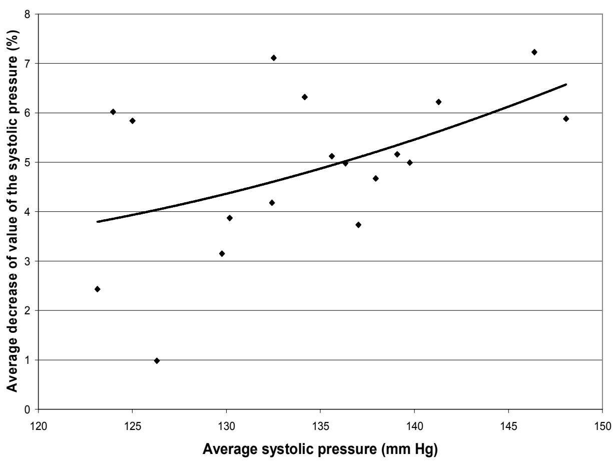

Fig. 3. Average drops of the systolic pressure in the function of its original value measured on persons subjected to the influence of negative air-ions at a concentration of 10,000 ions/cm^3.

Table 3. Mean of circulatory indicators and their changes measured on persons subjected to the influence of negative air-ions at a concentration of 10,000 ions/cm³, with reference to test measurements.

Persons	Systolic pressure			Diastolic pressure			HR (pulse)		
	$(0\ h)_{av}$ (mm Hg)	$\Delta\overline{x}$ (%)	p <	$(0\ h)_{av}$ (mm Hg)	$\Delta\overline{x}$ (%)	p <	$(0\ h)_{av}$ (1/min)	$\Delta\overline{x}$ (%)	p <
1	148.06	-5.88 (5.29)	0.002	83.24	-0.81 (0.74)	0.011	89.13	-2.15 (5.01)	0.125
2	146.38	-7.23 (6.51)	0.008	89.36	-2.53 (2.92)	0.019	88.34	1.12 (1.80)	0.055
3	141.29	-6.22 (3.07)	0.000	92.31	-4.82 (6.03)	0.015	71.37	-0.30 (0.67)	0.145
4	139.75	-4.99 (7.01)	0.040	77.06	-3.99 (7.58)	0.080	84.45	-5.72 (5.15)	0.006
5	139.08	-5.16 (3.35)	0.000	80.67	-3.75 (2.63)	0.002	79.00	-1.82 (2.29)	0.014
6	137.94	-4.67 (4.25)	0.006	83.88	1.14 (2.74)	0.150	83.55	-3.62 (7.60)	0.120
7	137.02	-3.73 (3.17)	0.007	87.35	-2.15 (1.94)	0.005	76.21	1.01 (2.01)	0.090
8	136.33	-4.98 (8.46)	0.055	69.92	0.01 (0.02)	0.090	95.00	-2.35 (4.23)	0.065
9	135.61	-5.12 (9.22)	0.070	85.22	-3.22 (4.77)	0.045	78.93	1.89 (3.79)	0.200
10	134.17	-6.32 (5.88)	0.000	79.49	-3.93 (3.30)	0.003	72.95	-8.23 (9.98)	0.050
11	132.52	-7.11 (7.10)	0.010	71.88	-2.43 (2.41)	0.010	82.96	1.23 (2.40)	0.095
12	132.43	-4.18 (3.85)	0.005	81.23	1.03 (1.96)	0.090	81.33	0.72 (1.39)	0.105
13	130.18	-3.87 (4.80)	0.025	78.41	-3.05 (4.36)	0.045	80.11	1.32 (2.27)	0.075
14	129.77	-3.15 (5.25)	0.055	74.44	-2.63 (2.34)	0.003	73.38	-3.41 (3.38)	0.008
15	126.31	-0.98 (2.35)	0.210	87.63	-0.88 (2.29)	0.150	75.81	-1.12 (1.68)	0.050
16	125.01	-5.84 (8.53)	0.035	68.65	-3.94 (6.35)	0.040	81.02	-3.54 (5.15)	0.045
17	123.98	-6.02 (4.82)	0.001	69.42	0.07 (0.07)	0.001	71.38	-1.37 (1.33)	0.010
18	123.15	-2.43 (2.14)	0.007	79.54	-2.90 (2.61)	0.005	72.90	-3.42 (3.47)	0.009
	–	$\Delta\overline{\overline{x}}$ (%) = -4.88	Δp = 0.00006	–	$\Delta\overline{\overline{x}}$ (%) = -2.15	Δp = 0.034	–	$\Delta\overline{\overline{x}}$ (%) = -1.65	Δp = 0.239

$(0\ h)_{av}$ – averaged, from all measuring days, initial test value of an index
$\Delta\overline{x}$ – averaged, from all measuring days, percentage changes of the value of an index after 6 h of the influence of negative air-ions
$\Delta\overline{\overline{x}}$ – averaged, for all 18 persons, values of $\Delta\overline{x}$
p – level of significance
Δp – averaged, for all 18 persons, values of p
(...) – size of standard deviation

With the results obtained in this mode presented in Table 4, another conclusion can be drawn – daily inhalation of air with negative air-ions of around 10,000 ions/cm^3 concentration results in lowering the systolic pressure not only during air-ion emission, but also later. The "initial" (i.e. for 0 hours) values of this indicator decreased gradually every day. Although this cannot be decisively stated based on the results of one person, the "0 hours" values presented in Fig. 4 for particular measurement days (columns 1 and 2 in Table 4) imply such a possibility. Lowering and then stabilizing the initial systolic pressure values is showed by the polynomial tendency line (degree 2) drawn in the graph.

The test results presented in Table 4 also imply that in the course of the following days a similar process, i.e. gradual lowering of the pressure values until reaching a stabilization level, also can occur in the case of diastolic pressure. However, data analysis shows that in this case the effect is less distinctive, and does not occur at all in the case of the pulse (this is why shifts in the values of this indicator were not presented in Table 4).

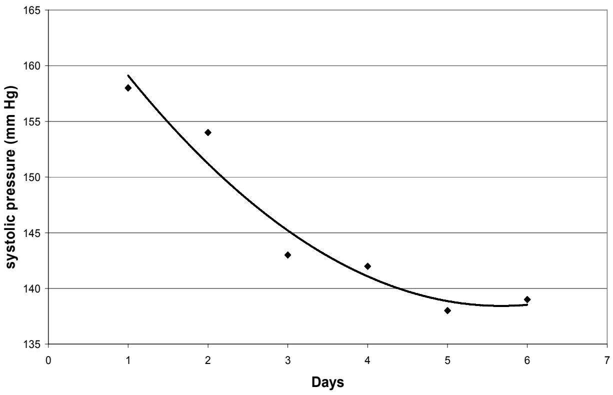

Fig. 4. Changes of the systolic pressure measured on a 28-year-old man subjected for consecutive days to the influence of negative air-ions at a concentration of 10,000 ions/cm^3.

Table 4. Changes in blood pressure measured on a 28-year-old man subjected for consecutive days to the influence of negative air-ions at a concentration of 10,000 ions/cm^3.

Days	Systolic pressure (mm Hg)		Δx (%)	Diastolic pressure (mm Hg)		Δx (%)
	0 h	6 h		0 h	6 h	
1	158	149	-5.70	99	86	-13.13
2	154	140	-9.09	97	82	-15.46
3	143	138	-6.12	86	80	-6.98
4	142	137	-3.52	85	88	3.53
5	138	133	-3.62	88	84	-4.55
6	139	132	-5.04	86	85	-1.16

Δx – percentage change of the value of an index after 6 h of the influence of air-ions.

Besides the experiments with negative air-ions, all persons compared in Table 3 were also exposed to positive ions. Yet in this case the test showed that a concentration of n^+ = 10,000 ions/cm^3 after 6 hours of exposure does not exhibit any statistically significant shifts from the initial level of human circulatory indicators. Therefore, in further experimental phase, the concentration of these particles was increased to the level of 25,000 ions/cm^3. Only at this level (which can thus be deemed critical) did shifts in both systolic and diastolic pressure start to occur, yet in a completely irregular fashion.

In the case of systolic pressure, this is depicted in Fig. 5 where mean daily shifts of this indicator in all 18 persons participating in the experiment were presented both for negative (for comparison purposes) and positive air-ions.

The averaged absolute percentage values of systolic pressure shifts for negative and positive air-ions presented in Fig. 5 are as follows: 4.822% and 5.434%. Although in

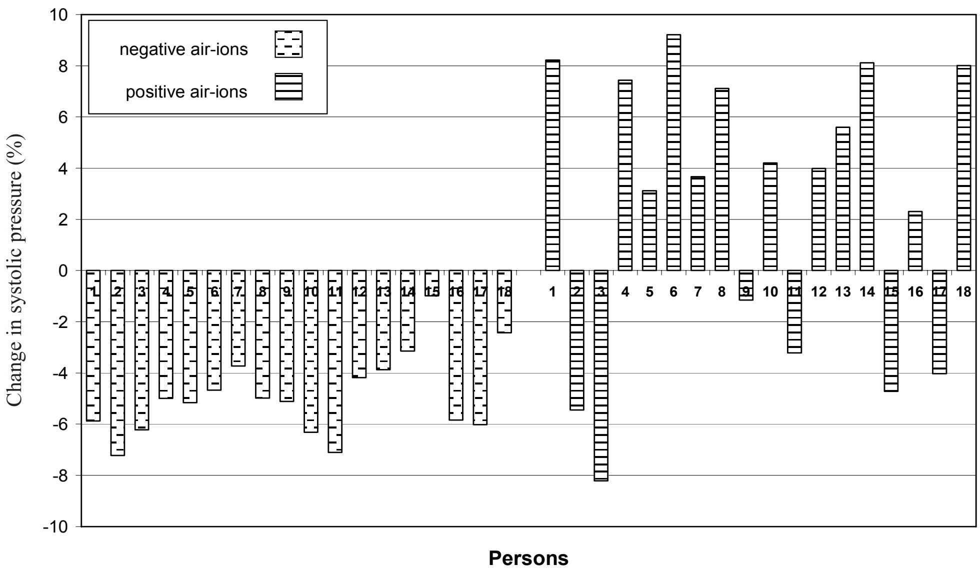

Fig. 5. Average changes of the systolic pressure measured on persons subjected to the influence of negative (10,000 ions/cm^3) and positive air-ions (25,000 ions/cm^3), with reference to test measurements.

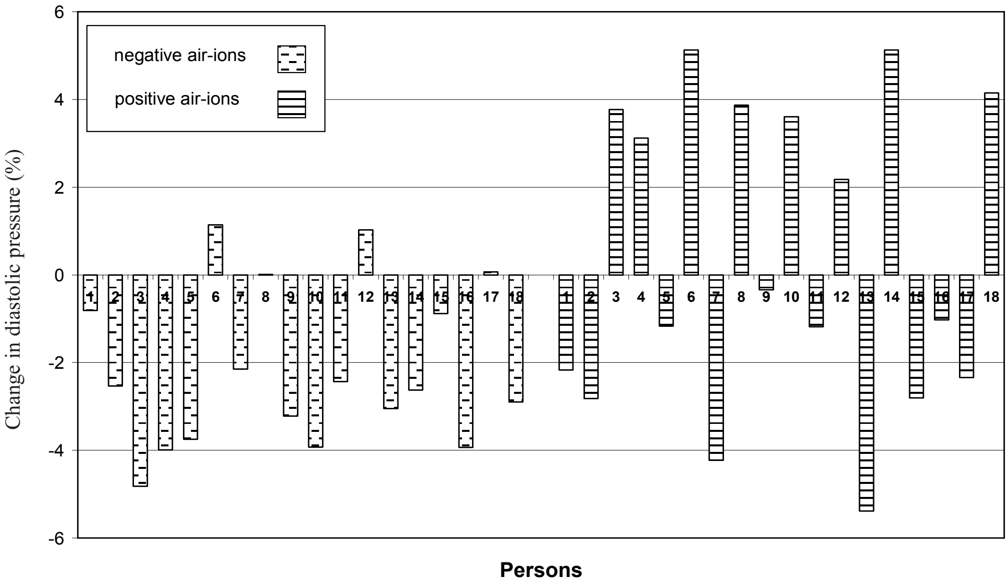

Fig. 6. Average changes of diastolic pressure measured on persons subjected to the influence of negative (10,000 ions/cm³) and positive air-ions (25,000 ions/cm³), with reference to test measurements.

the two cases the concentrations of the ionized particles were different (10,000 ions/cm³ for "–" and 25,000 ions/cm³ for "+"), they both can be deemed critical for triggering biological effects connected with blood circulation and thus can be compared. Therefore, the shifts in systolic pressure triggered by positive air-ions are not only of different directions but also slightly higher (by approx. 12.7%) than in the case of negative air-ions.

The situation is similar in the case of diastolic pressure, but its shifts triggered by positive air ions are smaller by approximately ½. When expressed in figures, they are much closer to their initial values. This is presented in Fig. 6, where test results for this indicator for the same persons are arranged in a similar layout (apart from the y axis) as in Fig. 5.

Persons exposed for 6 hours to the activity of positive air ions of the given concentration 25,000 ions/cm³ do not exhibit any repetitive effects connected with their pulse. It cannot even be stated that the positive air-ions trigger irregularity in pulse shifts.

Discussion

The test results obtained in this mode confirmed that air-ions of concentrations two or three times greater than in natural atmospheric background emitted for an extended period of time can affect human circulatory parameters. Above all, the tests show (at a good level of significance) that the negative ionized particles lower human systolic pressure. To a somewhat smaller extent they also lower the diastolic pressure.

The tests also helped to explain the mentioned issue of contradictory results of research into positive air-ions effect on people provided by different scientists [2, 25, 26], which gave rise to theorems that ionized particles do not affect people at all. In reality, positive air-ions also affect people, but by destabilizing their circulatory indicators. Therefore, the natural effect on people breathing air of higher positive air-ion concentration is sometimes a significant drop in circulatory parameters and sometimes a significant increase.

The obtained research results also show that the currently accepted standards (presented here in Table 1), are incorrect for two reasons. One is the fact that the standards do not specify the periods of time required for a person to stay in the atmosphere presented in Table 1 concentrations n^-, n^+ to experience the negative effects of exceeded bottom minimal or top maximal air ionization levels. If the time parameter is to be irrelevant for these standards, the specified "maximal, admissible" level is too high – already at the level of 25,000 ions/cm³, positive air-ions start to destabilize the human blood pressure level.

The obvious question which calls for an answer during analysis of the test results presented herein is about the biochemical or biophysical mechanism that enables triggering the biological effects (not only the shifts in circulatory indicators) by such small quantities of ionized particles in comparison to the quantities of neutral particles present in the air. This issue was not proposed to be addressed in the course of the research described here. The aim of the research was exclusively to determine whether air-ions of relatively small concentrations exposed to human organisms for an extended period of time can trigger any biological effects, and why different scientists had obtained contradictory results. This aim was achieved. However, it is vital to underscore that the outcomes of the research conducted so far have not determined one comprehensive biophysical or biochemical mechanism responsible for the fact that living organisms react to the increased level of air ionization. Among other things, air-ions affect living organisms through hydrated peroxide anion radicals [30], which stimulate the neuroendoctine cells (NEC) [2, 31] in human airways, or modify serotonin levels [32-35]. Sadly, many of these theorems are still in the hypothesis phase.

With the mechanism of air-ion influence on living organisms being undiscovered, the positive outcome of the research into the regulatory effects of negative air-ions on blood circulation raise a question whether this effect could be used in the treatment of circulatory diseases. Such an option cannot be confirmed or rejected based on the results presented here, yet it appears very probable.

To validate this hypothesis, research into the issue would need to be significantly extended as the tests presented here were designed merely to determine whether the ionized particles are able to trigger any biological or physiological reactions and, if so, at what concentrations. The research into the effects of air-ions on human circulatory parameters helped to establish that the minimal concentration of negative air-ions required to observe the drop in arterial pressure is approximately at the level of 10,000 ions/cm^3. But in this case, establishing this kind of critical value is not enough. Considering the application of ionized air for medical purposes, the optimal concentrations would need to be determined, which would lower the increased human arterial pressure most efficiently. Attempts to determine such optimal levels also were undertaken within the scope of this work. However, they were conducted at random and they showed that during negative air-ion exposure occurring over several hours, the optimal concentration level is within the range 25,000-40,000 ions/cm^3. Higher concentrations, as expected basing (among other things) on the mentioned results of tests on people performing physical exercise [23] and on *Staphylococcus epidermidis* [11] (in both cases the biological effects were destructive), triggered irregular, dynamic shifts in arterial pressure rather than a gradual drop in its value.

Unfortunately, precise specification of optimal values for negative air-ions (the suggested scope: 25,000-40,000 ions/cm^3 is too broad) to be applied at hypertension disease treatment is very difficult. Above all, the execution of such experiments faces technical hindrances. Significant expansion of the scope of the research needed to establish both different concentrations of emitted air-ions and exposure periods thereof would require installing a large number of experimental sites or extending the research duration. Furthermore, the tests would need to be conducted separately for groups of different ages – as most probably optimal air-ion concentrations are different for children, adults, and elderly people. However, the biggest problem consists of keeping the (Research Methods) rigorous requirements presented here which need to be met by persons subjected to the experiment. In the case of research presented here, the mentioned requirements were often violated, which automatically resulted in rejection of measurement outcome from a given day. Thus, even the tests presented here, limited to one concentration of the ionized particles and constant period of exposure, took more than 1.5 years.

Experiments on possible application of air-ions in treatment of hypertension face one more peculiar, yet very important, hindrance. The test results presented here consider exclusively persons of approximately appropriate circulatory indicators. The analysis of air-ionization as a possible therapeutic method, experiments with people of (significantly) increased arterial pressure who do not take any medicine would be required. Otherwise, relatively small drops in this indicator caused by negative air-ions (approx. 5%) could be eclipsed by other therapeutic activities. Therefore, conducting research into the possibility of using air-ions in hypertension treatment would only be justified if the patients subjected to the experiments would abandon all other therapies for the duration of the research. However, this requirement will not be accepted by the Bioethics Committee for Scientific Research.

Conclusions

- Exposing people for an extensive period of time (at least 6 hours a day for more than a dozen days) to the activity of negative air-ions of approximate concentrations of 5,000 ions/cm^3 does not trigger any statistically significant changes to their circulatory parameters.
- Exposing people of proper circulatory indicators for an extensive period of time (at least 6 hours a day for more than a dozen days) to the activity of negative air-ions of approximate concentrations of 10,000 ions/cm^3 results in lowering their systolic pressure by approximately 5% and their diastolic pressure by approximately 2%. Yet it does not affect the pulse. This effect works for both these pressures until they reach stable levels, which probably could be deemed optimal for a given person.
- Exposing a person of slightly too high circulatory parameters for an extensive period of time (i.e. at least 6 days) to the activity of exclusively negative air-ions of approximate concentrations of 10,000 ions/cm^3 results in gradual, daily lowering of both systolic and diastolic pressures by several percent. But it does not affect the pulse.
- The critical concentration of positive air-ions that can trigger changes in human circulatory indicators of significant level is approximately 25,000 ions/cm^3. However, inhaling air of such positive ionization levels does not trigger consistently directed shifts in these parameters, but introduces irregular shifts of their values in different directions.
- Comparing the effects of short-lasting exposure of air-ions to people performing physical effort with the effects of breathing the ionized air for an extensive period of time leads to a hardly verifiable, yet probable, hypothesis that the ionized particles affect the human organism in many different ways, not only through the lungs.

References

1. GRABARCZYK Z.J. Air ionization in environment of life and of work. CIOP: Warszawa, **2000** [In Polish].
2. KAVET R.I., CHARRY J.M. Air-ions: Physical and Biological Aspects. Boca Raton, Florida: CRC Press, Inc., **1987**.
3. DELEANU M., STAMATIU C. Influence of aeroionotherapy on some psychiatric symptoms. Int. J. Biometeorol. **29**, (1), 91, **1985**.

4. FLORY R., AMETEPE J., BOWERS B. A randomized, placebo-controlled trial of bright light and high-density negative air ions for treatment of Seasonal Affective Disorder. Psychiatry Research **177**, (1-2), 101, **2010**.
5. GIANNINI A.J., CASTELLANI S., DVOREDSKY A.E. Anxiety states: relationship to atmospheric cations and serotonin. J. Clin. Psychiatry, **44**, (7), 262, **1983**.
6. GIANNINI A.J., JONES B.T., LOISELLE R.H. Reversbility of seretonin irritation syndrome with atmospheric anions. J. Clin. Psychiatry **47**, (3), 141, **1986**.
7. HAWKINS L. The influence of air ions, temperature and humidity on subjective well beingand comfort. J. Environ. Psychol. **1**, 279, **1981**.
8. JURA Z., NIZIOŁ B., ZAKROCKI Z. Report No. 841 D of Institute of the Nuclear Physics. Ed. Institute of the Nuclear Physics: Kraków, **1973** [In Polish].
9. KORNIEWICZ H., GRABARCZYK Z., GRYZ K., KARPOWICZ J. Protection of human in work environment (CPBR No. 11.1). CIOP: Warszawa, **1991** [In Polish].
10. MALIK A., SINGH K., SINGH M. Effect of negative air ions on physiological and perceived psychological stress during computer operation. Int. J. of Environment and Health **4**, (1), 67, **2010**.
11. WISZNIEWSKI A., SZCZYGIEŁ M., HUDY S. Influence of Air-ions on Selected Microorganisms. Acta Microbiol. Pol. **52**, (2), 201, **2003**.
12. KLUSEK Z., WISZNIEWSKI A., JAKACKI J. Relationships between atmospheric positive electric charge densities and gas bubble concentrations in the Baltic Sea. Oceanologia **46**, (4), 459, **2004**.
13. SUCHANOWSKI A., WISZNIEWSKI A. Changes in ion concentration in the air during the breathing process of a human being. Pol. J. Environ. Stud. **8**, (4), 259, **1999**.
14. WISZNIEWSKI A. Natural environment of air-ions. Med. Pr. **48**, (4), 427, **1997** [In Polish].
15. WISZNIEWSKI A. Changes of the air ionization caused by electric discharge in the atmosphere. Ann. Acad. Med. Gedan. **34**, 341, **2004** [In Polish].
16. WISZNIEWSKI A. Air ionization in flats and offices. Hig. Pr. **3**, 37, **1997** [In Polish].
17. WISZNIEWSKI A. Normalization and optimization of air ionization levels in the atmosphere of populated areas. Med. Pr. **61**, (2), 441, **2010** [In Polish].
18. WISZNIEWSKI A., BARAN M. Changes in the state of air ionization caused by medical equipment. Med. Pr. **52**, (4), 271, **2001** [In Polish].
19. WISZNIEWSKI A., JANCZEWSKI D. Air-ions and their influence on human and animal organisms. Med. Pr. **3**, 289, **1993** [In Polish].
20. SCHREIBER G.O.S., PEYROUS R. Some air ion measurements made in the Pyrenees (France) at altitudes of 200 m and 2970 m. Int. J. Biometeorol. **23**, (2), 123, **1979**.
21. WISZNIEWSKI A. Environment of air-ions in ship cabins and possibility of its optimization. Med. Pr. **61**, (3), 299, **2010** [In Polish].
22. WISZNIEWSKI A., KRETOWICZ T. A study on influence of different signs of air-ions on sister-chromatid exchange frequency and chromosome aberrations in human peripheral blood lymphocytes. J. Appl. Genet. **40**, (2), 129, **1999**.
23. WISZNIEWSKI A., SUCHANOWSKI A. The Influence of Air-ions on People Submitted to Physical Effort and in Rest. Pol. J. Environ. Stud. **17**, (5), 801, **2008**.
24. SIROTA T.V., SAFRONOVA V.G., AMELINA A.G., MALTSEVA V.N., AVKHACHEVA N.V., SOFIN A.D., YANIN V.A., MUBARAKSHINA E.K., ROMANOVA L.K., NOVOSELOV V.I. The effect of negative air ions on the respiratory organs and blood. Biophysics **53**, (5), 457, **2008**.
25. SOVIJARI A.R., ROSSET S., HYVARINEN J., FRANSSILA A., GRAEFFE G., LEHTIMAKI M. Effect of air ionization on heart rate and perceived exertion during a bicycle exercise test, a double-blind cross-over study. Europ. J. App. Physoliogy & Occup. Physiology **41**, (4), 285, **1979**.
26. WATANABE I., NORO H., OHTSUKA Y., MANO Y., AGISHI Y. Physical effects of negative air ions in a wet sauna. Int. J. Biometeorol. **40**, 107, **1997**.
27. GRASSI G., CIFKOVA R., LAURENT S., NARKIEWICZ K., REDON J., FARSANG C., VIIGIMAA M., ERDINE S., BRAMBILLA G., BOMBELLI M., DELL'ORO R., NOTARI M., MANCIA G. Blood pressure control and cardiovascular risk profile in hypertensive patients from central and eastern European countries: results of the BP-CARE study. Eur. Heart J. **32**, (24), 218, **2011**.
28. HEDNER T., KJELDSEN S., NARKIEWICZ K., OPARIL S. Blood pressure and migration. Blood Press, **19**, (2), 65, **2010**.
29. PRYSTUPA T., WOŁYŃSKA A., ŚLEŃSKI J. The effects of finish sauna on hemodynamics of the circulatory system in men and women. J. of Human Kinetics **22**, (1), 100, **2009**.
30. KELLOGG III E.W., YOST M.G., BARTHAKUR N., KRUEGER A.P. Superoxide involvment in the bactericidal effects of negative air ions on *Staphylococcus albus*. Nature **281**, (4), 400, **1979**.
31. MARTINAC I. On the biological effects of small air ions and the use of ionizers in occupied indoor environments. Kungl. Techniska Högskolan – A4 – serien nr 141, Falu Bookproduktion: Falun, **1993**.
32. KELLOGG III E.W., YOST M.G., REED E.Y., KRUEGER A.P. Long-term biological effects of air ions and D.C. electric fields on NAMRU mice: second year report. Int. J. Biometeorol. **29**, (3), 269, **1985**.
33. KRUEGER A.P., REED E.J., BROOK K.B., DAY M.B.. Air ion action on bacteria. Int. J. Biometeorol. **19**, 65, **1975**.
34. KRUEGER A.P., STRUBBE A.E., YOST M.G., REED E.J. Electric fields, small air ions and biological effects. Int. J. Biometeorol. **22**, (3), 202, **1978**.
35. KRUEGER A.P. The biological effects of air ions. Int. J. Biometeorol. **29**, (3), 205, **1985**.