Environmental Impact on Cardiovascular Health: The Role of Environmental Pollution

V.A. Anzorov[1,*], *S.V.* Moryakina[1], and *L.* Kulova[2]

[1]Kadyrov Chehchen State University, Grozny, Russia
[2]North Ossetian State Medical Academy, Vladikavkaz, Russia

Abstract. Air pollution has become a significant concern for public health, particularly regarding its impact on cardiovascular health. This paper explores the relationship between environmental factors, specifically air pollution, and cardiovascular diseases. Epidemiological studies have demonstrated a clear association between exposure to air pollutants such as particulate matter, nitrogen dioxide, sulfur dioxide, and ozone, and an increased risk of cardiovascular events including heart attacks, strokes, and hypertension. Mechanisms underlying this association include inflammation, oxidative stress, endothelial dysfunction, and autonomic nervous system imbalance. Vulnerable populations, such as the elderly, children, and individuals with pre-existing cardiovascular conditions, are particularly susceptible to the adverse effects of air pollution. Mitigation strategies including environmental regulations, urban planning, and public health interventions are crucial for reducing exposure to air pollutants and improving cardiovascular outcomes. This paper underscores the importance of addressing environmental factors in the prevention and management of cardiovascular diseases.

1 Introduction

Air pollution significantly affects blood pressure regulation. A meta-analysis of 17 studies, encompassing both short-term (6 studies) and long-term (11 studies) effects of air pollutants, including PM2.5, PM10, and NOx, revealed an increased incidence of arterial hypertension. Notably, air pollution, primarily generated by combustion processes, can arise from industrial activities as well as natural sources, such as wildfires. Recent reports from the Athens 2021 wildfires indicated a 54.68% increase in PM2.5 concentration, which correlated with a 2.1 mmHg rise in systolic blood pressure (SBP) among 20 patients undergoing antihypertensive treatment. Multivariate regression analysis further confirmed the independent association between changes in PM2.5 concentration and SBP variation. Despite the limited sample size, these findings underscore the potential adverse cardiovascular effects of climate change in the future.

It took millions of years for the existing biological systems to form. The development, improvement and strengthening of the body's immune system occurs due to the influence of biorhythms. The transitions of the seasons of the year have a huge impact on the

[*]Corresponding author: vaha-anzorov@mail.ru

processes of human life, although he does not notice them. Environmental factors influence every cell of the body.The hypothalamic-pituitary system regulates physiological rhythms in humans and animals.

Determination of the state of physiological functions, adaptive reserves and resistance of the body is carried out through the study of biological rhythms.

Research in recent years has shown that the main synchronizer of daily and seasonal rhythms is the length of daylight hours. Seasonal rhythms were shaped by the changing seasons.

Hippocrates and Avicenna were the first to draw attention to the existence of a connection between the season of the year and the state of the body's systems.

It took a lot of time to scientifically substantiate this connection. The main task of a person is to preserve the natural abilities of the body, and this is solved through high sensitivity to oneself, one's physical and mental state.

According to A.A. Ukhtomsky, the time of assimilation of biological rhythms can vary widely.

The degree of compliance of the processes occurring in the body with natural seasonal changes determines a person's ability to adapt to the external environment, his resistance to stress and mental predisposition.

In sports medicine, occupational physiology and clinical diagnosis, physiological rhythms play a huge role. With various diseases and with overwork of the body, they can be disrupted.

If a person stops following the call of nature, deviations from the biorhythm system occur in his body.

The adaptation processes of future generations are negatively affected by disruptions in cell activity and the transmission of hereditary material, caused by minor deviations from seasonal biorhythms and natural needs.

Functional changes in the body are caused by changes in the seasons of nutrition, ambient temperature, solar radiation and the function of the endocrine glands, which regulate the reproductive function. In this connection, the assessment of seasonal changes occurring in the body is equated in importance to life itself.

In recent years, the interest of doctors and physiologists in seasonal changes occurring in the human body has grown significantly. The efficiency of determining the state of the body and treating various diseases will significantly increase by identifying the sequence of changes in body functions that occur over a certain period of time.

Choosing the time to take medications, especially hormonal substances, and creating a rational work and rest schedule require taking into account physiological rhythms.

In this connection, studying the state of the cardiovascular system of female students in different periods of the year is significant.

2 Research methodology

Air pollution is comprised of a combination of particulate matter (PM), gases, and gaseous co-pollutants, with particles ranging from nanometers to micrometers in size. Particulate matter can be coarse (PM10), fine (PM2.5), or ultrafine. Gaseous pollutants include nitrogen, sulfur oxides, volatile organic chemicals (VOCs), and secondary pollutants like ozone and various acids.

PM10 pollution primarily originates from industries, mining, and construction, while PM2.5 pollution is mainly caused by combustion of fossil fuels, biomass, or agricultural residue burning. Ultrafine particles, along with VOCs, are often emitted from vehicle exhaust. In winter, smog—a mixture of PM2.5 and fog—becomes prevalent. According to the World Health Organization (WHO), the acceptable daily levels of PM2.5 are 10 μg/m^3

for the annual mean and 25 μg/m³ for the 24-hour mean. For PM10, the acceptable levels are 20 μg/m³ for the annual mean and 50 μg/m³ for the 24-hour mean. However, standards are less stringent, with PM2.5 levels set at 40 μg/m³ for the annual mean and 60 μg/m³ for the 24-hour mean, and PM10 levels set at 60 μg/m³ for the annual mean and 100 μg/m³ for the 24-hour mean.

The study respondents were thirty-five full-time female students. Data from the summer season of the year were considered initial. The readings were taken in comfortable conditions once in each season of the year. Considering that in the average month of each season of the year, weather and climatic conditions characteristic of the season are established, the indicators were determined in January, April, June and October.

Cardiovascular system indicators were determined using an OMRON M3 Expert tonometer and an Alton-03 electrocardiograph. The experimental data were statistically processed by the Biostatistics program. Student's t-test was used to compare group indicators.

3 Results and Discussions

Environmental pollution is recognized as a significant contributor to non-communicable diseases, including cardiovascular diseases (CVDs), in Russia. Air pollution, resulting from a complex interplay of chemical, physical, and biological agents, stands out as a leading cause of mortality and morbidity among the Russian population. It is estimated to account for 7.6% of global mortality. Studies conducted in northern regions of Russia have highlighted the substantial increase in the risk of ischemic heart disease and stroke associated with long-term exposure to particulate matter < 2.5 μm (PM2.5), nearly doubling the risk for heart disease and elevating the risk for stroke by almost 10%.

The adverse effects of air pollution on the cardiovascular system are particularly pronounced in vulnerable populations within Russia, such as the elderly, individuals with pre-existing heart conditions, and those who are obese. Consequently, contemporary strategies for cardiovascular prevention in Russia advocate not only for the management of traditional risk factors but also for interventions aimed at improving the environmental quality. Achieving this goal necessitates the implementation of health surveillance practices in occupational medicine across various industries and sectors in Russia. Additionally, it underscores the importance of enforcing national and international legislative measures to mitigate environmental pollution.

The research results are shown in tables 1-2 and figure 1.

It follows from them that only the systolic blood pressure (SBP) of female students is subject to statistically significant changes by season.

Table 1. Heart rate and blood pressure of girls in different seasons of the year

Season of the year	Indicators		
	Heart rate in beats per minute	Blood pressure in mm Hg. Art.	ADD in mm Hg. Art.
Summer	79,2±1,84	115,9±2,52	74,6±1,66
Autumn	81,7±1,97	123,0±2,91	75,9±1,78
Winter	83,2±2,14	130,9±3,07***	78,8±2,03
Spring	80,8±1,81	123,6±2,73	75,0±1,68

*** – P < 0,01

Thus, the blood pressure level is higher in autumn by 7.1 mm Hg. Art., in winter – 15.0 (P < 0.01) and in spring – 7.7 mm Hg. Art. relative to the size of the summer season of the year.

The value of diastolic blood pressure (DBP) in the group increased by 1.3 mmHg in the autumn season of the year. Art., in winter – 4.2 and in spring – 0.4 mm Hg. Art. compared to the level of girls in the control group.

The maximum level of heart rate (HR) in the group was detected in the winter period of the year. Thus, in this season of the year, the increase in heart rate in girls was 4.0 beats per minute relative to the initial level.

It took 0.004 s less time to cover the atrial excitation in the spring season compared to the initial level.

In the winter and spring seasons of the year, the time of excitation from the atria to the ventricles is shorter by 0.007 s relative to the level of the summer season of the year.

The time of coverage of ventricular excitation decreased in winter by 0.004 s compared to the summer level.

Table 2. Electrocardiogram indicators of girls depending on the season of the year

Season of the year	Indicators, s			
	P	PQ	QRS	QT
Summer	0,073±0,0015	0,148±0,0035	0,078±0,0019	0,377±0,0093
Autumn	0,072±0,0016	0,144±0,0034	0,080±0,0018	0,368±0,0083
Winter	0,072±0,0014	0,141±0,0030	0,074±0,0017	0,358±0,0103
Spring	0,069±0,017	0,141±0,0031	0,079±0,0020	0,369±0,0082

The duration of ventricular systole in the winter period of the year decreased by 0.019 s relative to the initial level. Our results are confirmed by other researchers. Thus, an analysis of the results of studies by various authors indicates the presence of seasonal fluctuations in the level of blood pressure [13, 5].

According to various researchers, it has been established that in the summer season the level of blood pressure decreases significantly, and in the winter season it increases [15, 2].

Studies conducted by T. Kimura et al [7] at home on people in adulthood showed that blood pressure is higher in February and lower in August.

Based on the results of their studies [4, 6], they established that in winter there is an increase in blood pressure, and in summer it decreases.

Moreover, in winter, the heart rate is 5% higher, the amount of blood ejected by the heart per contraction is 10% higher, and the increase in peripheral blood resistance is 11% [10].

It is believed that an increase in the activity of the sympathetic branch of the autonomic nervous system in the winter season is the cause of high blood pressure in children and adults during this period of the year, and its decrease is the cause of low blood pressure in the summer.

According to various authors, the main reasons for seasonal changes in blood pressure and heart rate are listed below.

Apparently, an increase in the level of adrenaline and norepinephrine causes an increase in blood pressure.

The concentration of adrenaline and norepinephrine increases in the winter season and decreases in the summer, reports [14].

The higher the temperature drop in the environment, the higher the blood pressure. The difference in blood pressure between winter and summer is 16%.

According to [9], the reasons for seasonal changes are both fluctuations in ambient temperature and daylight hours.

An increase in blood pressure occurs due to a decrease in daylight hours, while the concentration of vitamin D in the blood decreases, which in turn increases the activity of the renin-angiotensin system [3, 12].

In addition to all this, an increase in blood pressure is caused by a narrowing of the blood vessels of the skin when exposed to cold [8].

A decrease in blood pressure in summer occurs due to increased sweating and increased excretion of sodium cations from the body [1].

According to G. Rose [11], due to various disorders in the functional activity of the cardiovascular system, mortality increases during the winter season.

Thus, in the winter season, systolic blood pressure is significantly higher, diastolic blood pressure and heart rate are insignificantly higher, and the time of waves and segments of the electrocardiogram is slightly shorter compared to the summer season.

4 Conclusions

Air pollution stems from a complex amalgamation of chemical, physical, and biological agents, the composition of which varies based on factors like geographic location, weather patterns, population density, and industrial activity. Today, it stands as a prominent cause of both mortality and morbidity worldwide, with the Global Burden of Disease estimating that air pollution is accountable for 7.6% of global deaths. Specifically, the World Air Quality Report of 2019 reveals that 24% of stroke-related deaths and 25% of deaths from ischemic heart disease can be linked to air pollution.

Atmospheric particulate matter and gases constitute the primary determinants of air pollution. Particulate matter refers to a mixture of solid and liquid particles suspended in the air, with sizes ranging from a few nanometers to 100 μm. This matter is categorized as PM10 (particles < 10 μm) and PM2.5 (particles < 2.5 μm). Ultrafine particulate matter, PM0.1 (particles < 0.1 μm), primarily originates from combustion processes, is prevalent in densely populated urban and industrial regions, and poses significant health risks due to its ability to penetrate deep into the respiratory system.

Moreover, the use of fossil fuels produces nitrogen oxides (NOx), which further exacerbate air quality degradation. NOx reacts with oxygen to form nitrogen dioxide (NO2), an airway irritant that contributes to the generation of ozone and nitric acid, thus perpetuating air pollution-related health hazards.

In our pursuit of improving cardiovascular health, it's essential to understand that the healthcare sector alone cannot guarantee a healthy life expectancy. Collaborative efforts spanning various sectors, including agriculture, transportation, environment, and fiscal policies, are vital to address key factors like diet, physical inactivity, and tobacco use. Only through cooperation across sectors can we achieve a positive impact on cardiovascular health and encourage countries and businesses to invest resources in our shared goal.

As negotiations on the Sustainable Development Goals (SDGs) advance, the cardiovascular disease (CVD) community finds itself at a crucial moment. It's imperative for us to utilize evidence-based science and advocacy to ensure that health remains a central focus of the UN Global Development Agenda. We call on governments to prioritize health, non-communicable diseases (NCDs), and other critical areas crucial for preventing and managing CVD and stroke. Through unified efforts, we can achieve sustainable human development.

References

1. Y.Y. Al-Tamer, Age dependent reference intervals of glucose, urea, protein, lactate and electrolytes in thermally induced sweat, 32 (1994)
2. M. Fedecostante, Summer does not always mean lower: seasonality of 24h, daytime, and night-time blood pressure, 30 (2012)

3. J.P. Forman, Vitamin D and Risk of Hypertension. Plasma 25-Hydroxyvitamin D Levels and Risk of Incident Hypertension, 49 (2007)
4. A. Hozawa, Seasonal variation in home blood pressure measurements and relation to outside temperature in Japan, 33-36 (2011)
5. T. Kimura, Seasonal blood pressure variation and its relationship to environmental temperature in healthy elderly Japanese studied by home measurements, 32 (2010)
6. B.R. Kingma, Increased systolic blood pressure after mild cold and rewarming: relation to cold-induced thermogenesis and age, 203-206 (2011)
7. P.A. Modesti, Seasonal blood pressure changes: an independent relationship with temperature and daylight hours, 61-64 (2013)
8. K.J. Radke, Seasonal variation in haemodynamics and blood pressure-regulating hormones, 24-29 (2010)
9. S.G. Rostand, Ultraviolet Light May Contribute to Geographic and Racial Blood Pressure Differences, 30 (1997)
10. R. Sega, Seasonal variation in home ambulatory blood pressure in the PAMELA population. Pressione Arteriose Monitorate E Loro Associazioni, 16 (1998)