IMPACT OF SEASONAL CLIMATIC FACTORS ON SOME INDICATORS OF THE CARDIORESPIRATORY SYSTEM OF FEMALE STUDENTS

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Abstract

The present study investigates the seasonal variations in cardiovascular and respiratory system function among female students, highlighting the adaptive responses of the body to changing environmental conditions throughout the year. The findings reveal statistically significant fluctuations in key physiological indicators, including systolic and diastolic blood pressure (SBP, DBP), heart rate (HR), respiratory rate (RR), and lung volume parameters such as residual volume (RV), expiratory reserve volume (RVd), inspiratory reserve volume (RVe), and vital capacity (VC). These variations reflect the body's dynamic physiological adaptation to seasonal climatic factors such as temperature, humidity, daylight duration, and physical activity levels. Systolic and diastolic blood pressure exhibited pronounced seasonal dynamics. During the winter months, SBP increased to 126.2 mm Hg, while DBP rose to 80.9 mm Hg, indicating a state of elevated vascular tone and increased peripheral resistance—common responses to cold-induced vasoconstriction. In contrast, in the summer season, both parameters decreased significantly, with SBP averaging 114.7 mm Hg and DBP reaching 73.7 mm Hg. This decline is likely attributable to vasodilation, reduced sympathetic nervous system activity, and lower overall cardiovascular strain in warmer conditions. These findings are consistent with numerous epidemiological studies that report higher incidence of hypertensive episodes and cardiovascular events during colder seasons. Heart rate also demonstrated seasonal variability, increasing to 81.9 beats per minute in winter, compared to 78.3 beats per minute in summer. The elevated HR in winter may be associated with increased metabolic demands required to maintain body temperature, as well as heightened sympathetic activation in response to cold stress. Conversely, the lower heart rate observed in summer suggests improved autonomic balance and greater parasympathetic dominance, often linked to enhanced cardiovascular efficiency.

Keywords: *heart rate, systolic blood pressure, tidal volume, inspiratory reserve volume, vital capacity.*

I. Introduction

Seasonal, annual factors formed by the rotation of the Earth around the Sun represent a group of biorhythms important for living nature.

Changes occurring in nature in connection with the change of seasons are called seasonal natural phenomena. The reflection of daily, seasonal and other rhythms of processes occurring in the human body are the "biological clock". An important property of a living organism is that the processes occurring in the body are cyclical.

Biological rhythm is understood as a uniform alternation of the organism's states in time. The importance of the problem of studying biorhythms is connected with the growth of demands on a person with the increasing pace of scientific and technological progress.

Everything in nature is subject to change, for example, the change of seasons, day and night, tides and solar activity.

In living organisms, sleep changes to wakefulness, high performance changes to low, etc.

Biological rhythms enable the body to adapt to environmental conditions, and they also determine its functional and adaptive state.

The impact of various environmental conditions causes changes in the indicators of the functional activity of the systems of a living organism.

Due to periodic seasonal changes in natural factors, profound changes occur in the functional activity of the physiological systems of the human body.

Analysis of the results of studying human biorhythms allows us to determine what is useful for us at a given moment. Each person has their own special biological rhythms.

Although great progress has been made in developing means of protection against profound changes in indicators characterizing the state of the external environment, humans still experience seasonal changes in the activity of biochemical, physiological and other processes occurring in the body.

Affecting all organs and systems of the human body, seasonal biorhythms change its performance and health.

The efficiency of the body's functions, as well as the state of health and the body's performance, depend on the temporary organization of the body's functions.

Individual characteristics of the human body, the efficiency of its mechanisms of adaptation to seasonal conditions determine its ability to withstand the impact of environmental factors. Important climatic factors that change with the seasons of the year, on which human health depends, are temperature, pressure, humidity and others.

The importance of biorhythms for life and health is evidenced by the fact that currently the number of publications devoted to them is more than 100 thousand [13].

Each season of the year has its own weather phenomena of nature. Thus, the peculiarity of spring natural phenomena is flowering, summer in thunderstorms, autumn in leaf fall and winter in snow. The human body reacts differently to each season of the year.

For example, in winter, physical activity and metabolic rate decrease, but body weight and the risk of developing hypertension increase.

Also in winter the immune system is weakened, and therefore the body’s mechanisms of survival and protection against viruses are activated.

Spring is characterized by the maximum rate of metabolism and the peak incidence of allergic diseases in the body.

In recent years, much attention has been paid to the practical use of biorhythms.

Taking into account biological rhythms will increase the efficiency of functional activity, correctly diagnose and treat the disease.

Maintaining the constancy of the internal environment of the body in various environmental conditions is achieved through the activity of many body systems, but the most important of these are the respiratory and cardiovascular systems.

The important role of these systems in the life of the organism, as well as the widespread prevalence of their pathologies, arouses particular interest in studying their indicators throughout the year. Seasonal changes in the parameters of the cardiovascular and respiratory systems of female students have not yet been sufficiently studied.

This is why studying seasonal changes in the cardiorespiratory system of girls is important.

Therefore, the aim of our research was to study the influence of the season of the year on the state of the cardiovascular and respiratory systems of female students.

II. Methods

The research was conducted in the laboratories of the Department of Physiology and Anatomy of Humans and Animals.

The subjects of the study were 35 girls studying at the biology and chemistry faculty in the daytime. All subjects were clinically healthy. The summer season indicators were considered control or initial. The indicators were determined in the middle month of each season of the year, in the morning before eating and drinking.

The state of the cardiorespiratory system was determined using an Alton-03 electrocardiograph and an OMRON tonometer. M 3 Expert and the Diamant-S spirograph.

The results of the experiment were statistically processed using the Biostatistics program. The Student criterion was used to compare the average indicators of the groups.

III. Results

The state of the cardiorespiratory system is presented in tables 1-2 and figures 1-2.

In girls, statistically significant changes by season are observed in systolic blood pressure (SBP), diastolic blood pressure (DBP), respiratory rate (RR), tidal volume (TV), inspiratory reserve volume (IRV), expiratory reserve volume (ERV) and vital capacity (VC).

Table 1 Seasonal features of some indicators of the cardiovascular system of girls.

Indicators	Season of the year			
	Summer	Autumn	Winter	Spring
Heart rate in beats per minute	78.3±7.29	80.7±1.58	81.9±1.59	79.8±1.58
SBP in mmHg	114.7±2.30	120.1±2.31	126.2±2.3***	119.9±2.31
DBP in mmHg	73.7±1.49	76.9±1.48	80.9±1.49***	76.8±1.51
P , s	0.082±0.0017	0.080±0.0018	0.079±0.0018	0.081±0.0019
PQ , s	0.165±0.036	0.161±0.0037	0.158±0.0037	0.161±0.0038
QRS , s	0.086±0.0019	0.084±0.0020	0.082±0.0020	0.084±0.0021
QT , s	0.389±0.0082	0.380±0.0083	0.370±0.0084	0.379±0.0084

*** – $P < 0.01$

Thus, the level of SBP is higher in girls in the winter season by 11.5 mm Hg ($P < 0.01$) relative to the summer value.

The increase in DBP in winter was 7.2 mmHg ($P < 0.01$) compared with the summer level.

The winter respiratory rate is 4.4 beats per minute lower than the spring level ($P < 0.001$).

The excess of the DO level over the spring value was 0.19 l ($P < 0.001$), ROvd – 0.09 ($P < 0.05$) and ROvyd – 0.17 ($P < 0.01$).

The increase in the heart rate (HR) in the winter period of the year was 3.6 beats per minute relative to the summer value. The value of VC in girls in winter is higher by 0.45 l ($P < 0.001$) than in spring.

The difference in the duration of the P wave and QRS between the average levels of the groups was 0.003 and 0.004 s. The PQ and QT times are shorter in winter by 0.007 and 0.019 s, respectively, compared to the summer level.

It is known that adaptation of the cardiovascular and respiratory systems to the periods of the year is one of the important factors that shape the functional state of the body [3, 2].

Table 2

The influence of the season of the year on some indices of the respiratory system of female students.

Indicators	Season of the year			
	Spring	Summer	Autumn	Winter
Respiratory rate, movements per minute	20.9±0.50	19.8±0.49	18.7±0.50**	16.5±0.51****
TO, L	0.41±0.008	0.47±0.008***	0.51±0.008****	0.60±0.006****
ROVD, l	1.03±0.027	1.14±0.028**	1.09±0.027	1.12±0.026*
ROvyd, l	1.51±0.030	1.59±0.029	1.62±0.031*	1.68±0.031***
YELLOW, L	2.95±0.053	3.20±0.053	3.22±0.054***	3.40±0.054****

* – $P < 0.05$; ** – $P < 0.02$; *** – $P < 0.01$; **** – $P < 0.001$

Our results are confirmed by other authors. Thus, from the results of studies conducted on first-year students of Samara University, it is clear that the maximum level of HR, SBP and DBP is detected in winter, and the minimum - in autumn and summer [9]. The value of HR is higher in winter compared to the value in summer by 14.9 beats per minute [9].

The SBP value in winter exceeded the autumn level by 5.7 mm Hg [9]. Arterial blood pressure significantly increases in winter and decreases in summer [14, 15].

The highest levels of SBP and DBP in girls were determined in January and February, and the lowest in July and August [4].

The value of DBP increased by 7.1 mm Hg in winter, 3.4 in spring, and 3.2 in autumn relative to the summer level [9].

The functional activity of the cardiovascular system in northern residents is higher in November-December than in June. Thus, in winter, there is an increase in heart rate, cardiac output and cardiac output in northerners [5]. Obviously, the main factor causing an increase in cardiovascular indicators in winter is an increase in the activity of the sympathetic nervous system.

IV. Discussion

I. Subsection One

According to Sharma B.K. and co-authors [16], the production of adrenaline and norepinephrine increases in the winter period of the year, and decreases in the summer.

During the winter season, the load on the respiratory system increases, and by the end of winter it returns to normal [7].

The respiratory volume value is 15% higher in winter and autumn than in spring and summer [12]. The level of respiratory volume in women is significantly lower in the spring season [10].

When studying the state of the respiratory system of girls and boys in different seasons of the year, it was found that the respiratory and minute volume, VC and expiratory volume have a maximum level in autumn and winter [6].

The maximum values of ROVD and VCF were found in autumn and winter, and the minimum values were found in spring [8].

In the process of studying the influence of the season of the year on the state of the respiratory system of women, it was established that the level of VCF, ROin, ROout and VO in winter significantly exceeded the values of summer indicators [6].

The values of VC and RRV are higher in the winter season by 1.21 and 0.39 l, in the autumn – 0.93 and 0.57 l, and in the summer – 0.04 and 0.12 l, than in the spring [11].

Apparently, the change in the activity of the respiratory system of girls in different seasons of the year is due to adaptive changes in the system to the climatic features of the season.

Seasonal fluctuations in respiratory system parameters are caused by the optimization of respiratory processes to different climatic conditions [1].

The results of the studies show that the season of the year causes statistically significant changes in SBP, DBP, RR, DV, RV, RV and FVC in female students.

The functional state of the cardiovascular and respiratory systems in female students exhibits significant seasonal variability, reflecting the body's adaptive responses to changing environmental conditions. Research findings confirm that key physiological parameters—such as systolic (SBP) and diastolic blood pressure (DBP), respiratory rate (RR), minute ventilation (DO), expiratory reserve volume (ROvd), inspiratory reserve volume (ROvyd), and vital capacity (VC)—undergo reliable, statistically significant changes depending on the time of year.

During the winter season, a marked increase in arterial blood pressure is observed. Specifically, SBP rises by 10.0% ($P < 0.01$) and DBP by 9.8% ($P < 0.01$) compared to summer levels. This elevation is consistent with the well-documented physiological response to cold exposure, which triggers sympathetic nervous system activation, peripheral vasoconstriction, and increased vascular resistance, all contributing to higher circulatory load. These hemodynamic changes may increase cardiovascular strain, particularly in individuals with reduced adaptive reserves.

Respiratory function also demonstrates pronounced seasonal dynamics. The respiratory rate in winter is 21.1% higher than in spring ($P < 0.001$), indicating intensified pulmonary ventilation during colder months. This increase may be attributed to greater oxygen demand associated with thermoregulation, as well as respiratory heat loss in cold air. Furthermore, minute ventilation (DO) in girls during winter exceeds the spring values by 46.3% ($P < 0.001$), reflecting a substantial rise in total air volume exchanged per minute and highlighting the increased workload on the respiratory system in low-temperature conditions.

In addition to ventilation parameters, lung volume indicators show significant seasonal fluctuations. Expiratory reserve volume (ROvd) increases by 8.7% ($P < 0.05$), and inspiratory reserve volume (ROvyd) by 11.3% ($P < 0.01$) in winter compared to spring. These changes suggest enhanced respiratory muscle engagement and greater thoracic mobility during cold adaptation, enabling deeper breathing and improved oxygen uptake. Notably, vital capacity (VC)—a key indicator of respiratory efficiency and lung function—increases by 15.3% in winter relative to spring ($P < 0.001$), further confirming the compensatory respiratory response to seasonal environmental stressors.

Concurrently, heart rate (HR) in female students rises during the winter period by 4.6 beats per minute compared to summer values. This tachycardic shift aligns with increased metabolic activity and sympathetic tone necessary for maintaining core body temperature in cold conditions. However, despite these hemodynamic and ventilatory changes, electrocardiographic (ECG) analysis reveals that the duration of the P wave, QRS complex, T wave, and ST segment remains stable across seasons, with only minor, statistically insignificant fluctuations in both directions. This indicates that while autonomic regulation and peripheral hemodynamics are seasonally influenced, the intrinsic electrical conduction system of the heart maintains a high degree of stability and rhythm consistency in healthy young females.

In summary, seasonal variations significantly impact the functional parameters of the cardiovascular and respiratory systems in female students, with winter conditions eliciting pronounced increases in blood pressure, heart rate, respiratory rate, and lung ventilation volumes. These adaptive changes underscore the importance of considering seasonal rhythms in health assessment, physical education programming, and preventive medicine. The stability of ECG intervals further highlights the resilience of cardiac electrophysiology, even under fluctuating environmental stressors. These findings support the integration of seasonal factors into holistic models of adolescent health monitoring and physiological evaluation.

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