CLIMATE CHANGE IN MOUNTAINOUS REGIONS AND ITS IMPACT ON THE PHYSICAL DEVELOPMENT OF YOUNG PEOPLE: PROBLEMS AND PROSPECTS

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Abstract

This study examines the implications of climate change in mountainous regions on the physical development of young people. As climate patterns continue to shift, mountainous areas are experiencing alterations in temperature, precipitation, and seasonal cycles, which can significantly affect the growth and health of youth populations. The research highlights various problems arising from these changes, such as increased susceptibility to respiratory and cardiovascular diseases, altered nutrition due to changes in local agriculture, and the psychological impacts of environmental stressors. Moreover, the study identifies potential prospects for addressing these challenges through community engagement, health education, and policy interventions. It emphasizes the importance of fostering adaptive strategies to enhance resilience among young people in mountainous regions, ensuring their physical development is supported in the face of climate change. By implementing sustainable practices and promoting environmental awareness, communities can mitigate adverse effects and promote healthier futures for the youth. The levels of the mass-height index, Broca's index, Quetelet's index and maximum permissible mass in the mid-mountain region among girls decreased to 36.5 kg/cm, 56.0 kg, 362.5 g/cm and 51.7 kg, and on the plain they were 38.5; 62.7; 384.5 and 65.1, respectively. Among young men, at an altitude of 1600 m above sea level, there was a decrease in the values of the mass-height index, Broca's index, Quetelet's index and maximum permissible mass to 43.0 kg/cm, 62.7 kg, 429.9 g/cm and 63.1 kg, and the initial values were 44.2; 66.7; 441.5 and 78.5, respectively. The value of the vital index in low-mountain and mid-mountain conditions increased to 50.0 and 58.7 ml/kg for girls, to 60.6 and 66.3 for boys, and was 46.3 and 54.8 for control students.

Keywords: climate change, mountainous regions, body weight, vital capacity, mass-height index, Broca's index, vital index.

I. Introduction

Climate change poses one of the most significant challenges of the 21st century, impacting ecosystems, weather patterns, and human health across the globe. Mountainous regions, known for their unique biodiversity and distinct climatic conditions, are particularly vulnerable to the effects of climate change. As temperatures rise and weather patterns become increasingly unpredictable, the physical development of young people living in these areas is at risk.

Young people in mountainous regions face a myriad of environmental challenges that can adversely affect their growth and health. Factors such as increased air pollution, altered precipitation patterns leading to water scarcity, and the shifting availability of local food sources directly influence their nutrition, physical activity levels, and overall well-being. These changes can lead to an array of health issues, including respiratory illnesses, nutritional deficiencies, and reduced physical fitness. Moreover, the psychological impact of climate change, characterized by anxiety about the future and stress related to environmental instability, can further hinder the healthy development of youth.

Understanding the intricate relationship between climate change and the physical development of young people in mountainous regions is essential for developing effective interventions. This study aims to explore the multifaceted problems arising from climate change in these areas, while also identifying potential prospects for promoting resilience and adaptive strategies. By fostering community engagement and enhancing health education, stakeholders can play a vital role in addressing the challenges posed by climate change, ensuring the physical well-being and development of young people in mountainous regions.

This research not only highlights the pressing need for action but also emphasizes the importance of sustainable practices that can mitigate the effects of climate change. Ultimately, it seeks to provide insights that will contribute to healthier futures for young populations in vulnerable mountainous areas, enabling them to thrive despite the environmental challenges they face.

The physiological development of students living and studying in mountainous regions is shaped by unique environmental factors that distinguish these areas from lowland or urban settings. Mountain terrains are characterized by higher altitudes, lower atmospheric pressure, reduced oxygen levels, colder temperatures, and rugged landscapes, all of which contribute to a distinctive physical and physiological adaptation process in individuals.

This setting imposes various challenges on the human body, particularly during developmental stages such as adolescence, when the body is highly responsive to environmental conditions. Factors such as altitude-induced hypoxia (reduced oxygen supply), increased physical activity due to steep terrains, and the need for thermal regulation all play significant roles in shaping the growth, cardiovascular fitness, respiratory capacity, and overall stamina of students in these regions.

The unique demands of mountain environments stimulate specific adaptive responses, which can lead to variations in lung capacity, red blood cell production, muscular development, and metabolic efficiency compared to students living at lower altitudes. Understanding these physiological adaptations is critical for ensuring that educational and health programs are tailored to meet the needs of students in mountain regions.

This introduction sets the stage for exploring how the interplay of environmental stressors, physical activity, and altitude influences the physiological growth and health outcomes of students, highlighting both the benefits and challenges posed by mountainous terrains.

In various environmental conditions, the human body is capable of maintaining the constancy of the internal environment through adaptive responses, as well as regulating the functional activity of its systems due to the fact that it is a self-regulating and self-sustaining system.

In response to the effects of mountain hypoxia, the human body begins a process of adaptive reactions, primarily from the cardiorespiratory and nervous systems. People who are not prepared for the effects of mountain hypoxia begin to feel the negative effects of altitude at an altitude of 2500-3000 m above sea level. When healthy people climb mountains at an altitude of 4000 meters, every fifth person experiences symptoms of altitude sickness, the severity of which depends on the individual characteristics of the body. Residents living at an altitude of 4500 m experience adaptation disorders that lead to decreased performance.

Mountainous terrain above 4500 meters is uninhabited, and the conditions of this terrain have a negative impact on human health. The body's adaptive reactions disappear at an altitude of 6500-7000 meters [10].

Researchers have long established that prolonged exposure to high-altitude hypoxia is accompanied by an increase in the body's reserves and stimulation of the activity of vital body systems. At the same time, the negative impact of negative environmental factors is reduced. The process of adaptation to mountain conditions is to some extent controllable, but its effectiveness decreases at high altitudes. The number of people doing their jobs and enjoying active recreation in the mountains increases year after year. Therefore, research aimed at studying the state of human body systems and developing methods for preventing possible disruptions in their functioning in mountainous areas is relevant.

On the other hand, as the number of people living in mountainous conditions increases, the number of people exposed to the negative factors of this area increases. Therefore, determining the state of the body and its resistance to the effects of mountain conditions is of particular importance. This makes the study of the physiological development of students in mountainous areas important.

II. Methods

Laboratory equipment of the Department of Physiology and Anatomy of Humans and Animals was used to conduct the research.

The object of the study were 180 (90 girls and boys) clinically healthy full-time students. Of these, depending on the altitude of residence above sea level (Grozny - 170 m, Shatoi district - 600 m, Sharoi district - 1600 m), 3 groups were formed. Each group included thirty girls and boys. Residents of the plain were considered the control or first group, lowlanders - the second, and mid-mountains - the third.

To determine the physiological development of students, we used body weight, body length, maximum permissible weight according to B.I. Tkachenko 1994 and calculated indicators: mass-height indicator MHI = weight, kg x 100 / height, cm; body mass index BMI = weight, kg / height, m **2** ; vital index VI = VC, ml / weight, kg; Quetelet index CI = weight, g / height, cm; expected body weight according to Broca's index: for height up to 155 cm, weight = height, cm – 95; 156-165 cm, weight = height, cm – 100; 166-175 cm (height – 105); 175 and above (height – 110). The state of the respiratory system was studied using the Diamant-S spirograph.

Biometric control of experimental data was carried out using the Biostatistics program, comparison of average indicators of groups using the Student's criterion.

IV. Discussion

The weight, height and VC of students in the mountains are given in Tables 1-2 and Figures 1-2. From these tables and figures it is evident that in mountain conditions there is a statistically significant change in the weight, body length and VC of students.

Thus, the body length of girls and boys in the third group is 12.7 ($P < 0.01$) and 13.3 cm ($P < 0.02$) lower than the initial values.

Table 1: *Physical development indicators and vital capacity of lungs of girls*

Terrain	Height in cm	Body weight in kg	YELLOW in L
Plain	164.7±3.49	63.3±1.38	2.93±0.061
Lowlands	158.6±3.12	61.7±1.53	3.08±0.062
Middle Mountains	152.0±1.86***	55.1±0.83****	3.23±0.041***

*** – $P < 0.01$; **** – $P < 0.001$

The body weight of girls and boys living in mid-mountain conditions decreased by 8.2 ($P < 0.001$) and 7.8 kg ($P < 0.01$) compared to the values of lowland residents.

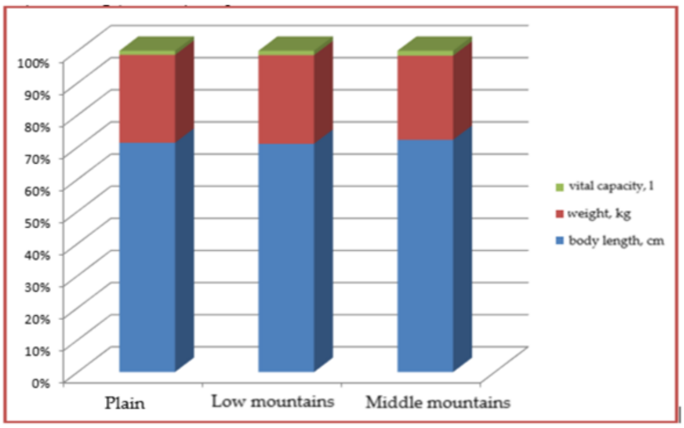

Figure 1: Height, weight and vital capacity of female students under hypoxic conditions

Our results are confirmed by other researchers. Thus, the distinctive features of mountain dwellers are short stature and reduced body weight [12]. Long-term residence in conditions of mountain hypoxia is accompanied by a decrease in body length and weight by an average of 13.5 cm and 9 kg [12]. Living in the highlands reduces a person's height and weight by 17.7 cm and 15.3 kg compared to lowland residents [11, 13, 8].

Most populations of people of different racial and ethnic origins living in mountainous areas are characterized by slow growth processes and large body sizes [2]. Due to the low body volume, highlanders consume less oxygen [5].

Exposure to mid-mountain conditions increased the level of vital capacity in girls by 0.30 l ($P < 0.01$) and in boys by 0.37 l ($P < 0.02$) relative to the values of the control groups.

People living in conditions of high-altitude hypoxia have a high number of respiratory movements per minute, high lung ventilation and lung capacity, as well as large respiratory volumes of the lungs [15].

Table 2: *Height, weight and vital capacity of young men*

Terrain	Height in cm	Body weight in kg	YELLOW in L
Plain	173.7±2.90	76.7±1.26	4.20±0.072
Lowlands	167.6±3.68	72.5±1.69	4.39±4.39±0.095
Middle Mountains	160.4±3.63**	68.9±1.39***	4.57±0.103**

** – $P < 0.02$; *** – $P < 0.01$

Aidaraliev A.A. [3] concluded from the results of his research that an increase in respiratory volume is the cause of increased lung ventilation in humans when exposed to hypoxia.

According to B. Messerli and J.D. Ives [7], as well as O.G. Gazenko [16], mountain dwellers have a large chest, high vital capacity and a high level of oxygen in the blood. At the beginning of the process of human adaptation to conditions of oxygen deficiency in the inhaled air, an increase in the amount of alveolar ventilation occurs [6]. An increase in the depth of breathing and ventilation of the lungs is the human body's response to the effects of insufficient oxygen content in the environment [14]. Apparently, exposure to high-altitude hypoxia causes an increase in the vital capacity of the lungs in students due to an increase in the tone of the inspiratory muscles.

Thus, due to the high tone of the inspiratory muscles, the vital capacity in conditions of high-altitude hypoxia is 10% greater [1]. Probably, due to the stimulation of the respiratory center by the oxygen deficiency, the strengthening of the respiratory system function is caused. When a person adapts to conditions of mountain hypoxia, the functional activity of the systems that supply the body with oxygen increases [9].

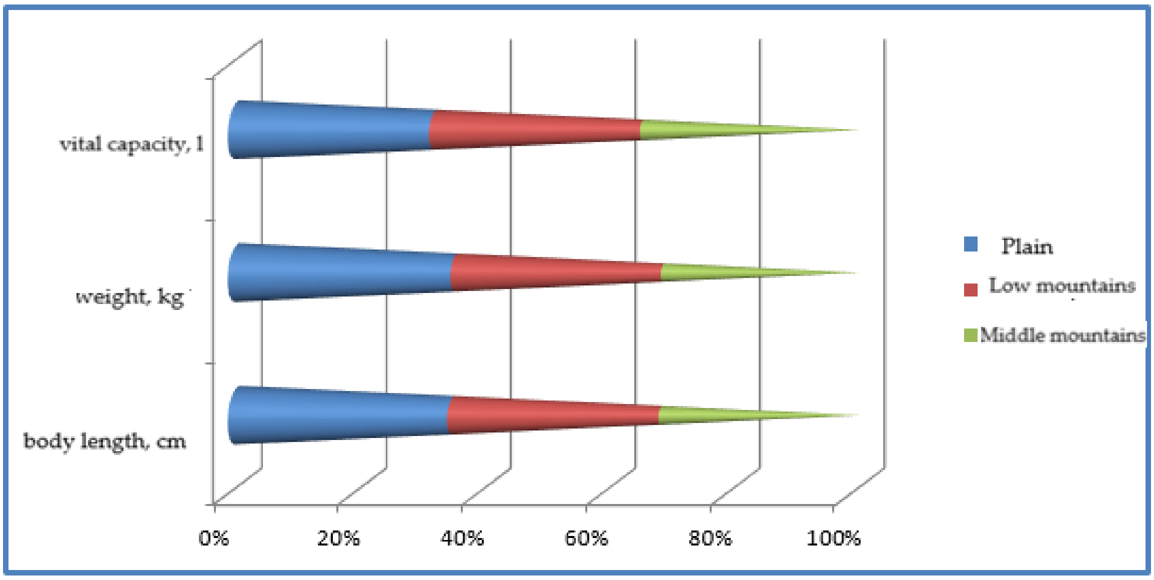

Figure 2: *Weight, height and vital capacity of young men under hypoxia*

Increased pulmonary ventilation and a reduction in the time of hemoglobin oxygen saturation are caused by low oxygen content in the external environment [4]. When exposed to hypoxia, statistically significant changes occur in the physiological development indicators of students, with the exception of body mass index (Table 3-4 and Fig. 3-4).

Thus, the value of the mass-height indicator in girls and boys in mid-mountain conditions is lower by 2.0 ($P < 0.001$) and 1.2 kg/cm ($P < 0.05$) relative to the initial level.

Table 3: *Indicators of physiological development of girls in conditions of mountain hypoxia*

Indicators	Altitude above sea level in meters		
	170	600	1600
Weight-height index, kg/cm	38.5±0.23	38.9±0.49	36.5±0.37****
Body mass index, kg/ m2	23.4±0.54	24.6±0.51	23.9±0.39
Broca's index, kg	62.7±1.72	59.1±1.84	56.0±1.05***
Vital index, ml/kg	46.3±0.28	50.0±0.66****	58.7±0.62****
Quetelet index, g/cm	384.5±2.30	388.8±4.86	362.5±3.67****
Maximum permissible weight, kg	65.1±3.72	58.5±3.18	51.7±1.91***

*** – $P < 0.01$; **** – $P < 0.001$

The MCI value of girls in the conditions of the plain and low mountains (38.5 and 38.9 kg/cm) indicates a normal ratio of body length and weight, and in the mid-mountain (36.5) - low nutrition. The level of MCI in the groups of boys shows their increased fatness.

The level of the Quetelet index in groups of men indicates the presence of excess weight. The decrease in the maximum permissible weight in girls and boys in the midlands was 13.4 ($P < 0.01$) and 15.4 kg ($P < 0.02$) relative to the values of the control students.

The maximum permissible weight for the group of girls in plain conditions is 1.8 kg higher than the actual weight, and for the second and third groups it is 3.2 and 3.4 kg lower, respectively. The actual weight of the boys in the first group is 1.8 kg lower than the maximum permissible weight, and in low-mountain and mid-mountain conditions it is 2.2 and 5.8 kg higher.

Thus, mountain hypoxia causes a reliable decrease in the level of mass-height index, Broca's index, Quetelet index, maximum permissible mass and a statistically significant increase in the vital index in students.

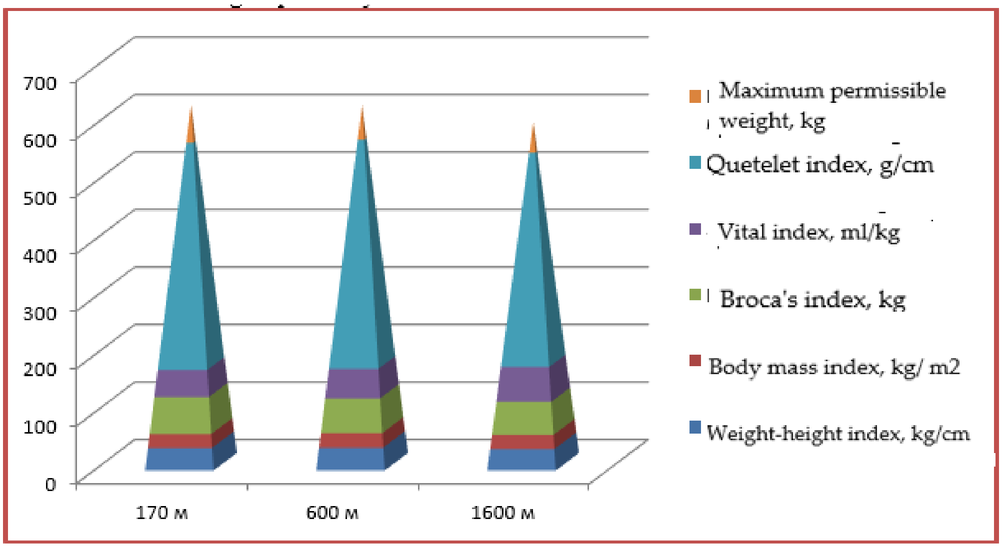

Figure 3: *The impact of hypoxia on physiological development indicators of female students*

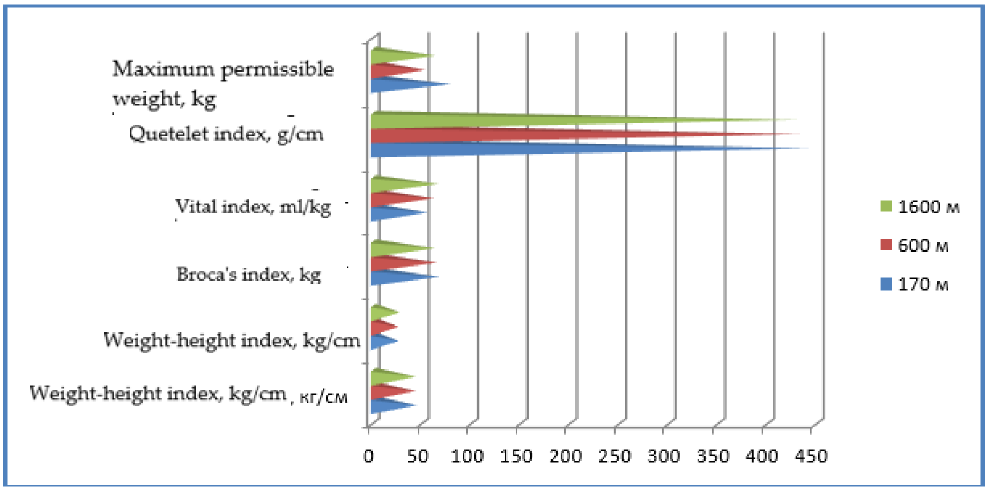

Figure 4: *The influence of mountain hypoxia on the physiological development of young men*

In girls and boys living in mid-mountain conditions, body height is 7.8 ($P < 0.01$) and 7.7% ($P < 0.02$) lower, and weight is 13.0 ($P < 0.001$) and 10.2% ($P < 0.01$) lower than in lowland residents.

At an altitude of 1600 m, the level of vital capacity in girls is 10.2% higher, and in boys it is 8.8% higher compared to the values of students in the control groups. Under conditions of high-altitude hypoxia, statistically significant changes occur in the values of the MRP, Broca's index, GI, IC, and the maximum permissible weight of students. The mass-height index of girls and their peers living in the mid-mountain regions is lower by 5.2 ($P < 0.001$) and 2.7% ($P < 0.05$) compared to the values of the first groups. In the mid-mountain region, the Broca index is 10.7% lower ($P < 0.01$) among girls, and 6.0 lower among boys relative to the baseline values. The level of vital index in girls and boys in the low mountains increased by 8.0 ($P < 0.001$) and 10.6% ($P < 0.001$), and in the mid-mountain regions by 26.8 ($P < 0.001$) and 21.0 ($P < 0.001$) compared to the values of students in the control groups. The Quetelet index value in mid-mountain conditions decreased by 5.7% ($P < 0.001$) among girls and by 2.6% ($P < 0.05$) among boys relative to the level of those living on the plain. The maximum allowable weight of girls and boys living in the mid-mountain areas decreased by 20.6 ($P < 0.01$) and 19.6% ($P < 0.02$) compared to the initial values.

The impact of climate change on the physical development of young people in mountainous regions is a complex interplay of environmental, social, and health factors. As this study outlines, the physiological effects of changing climate patterns can manifest in various ways, influencing the overall well-being and growth trajectories of youth. Understanding these interconnections is crucial for developing targeted interventions and policies.

One of the most immediate consequences of climate change in mountainous areas is the deterioration of air quality due to increased pollution and wildfires, leading to respiratory diseases. Young people, whose lungs and immune systems are still developing, are particularly vulnerable. Research has shown that children and adolescents living in areas with poor air quality experience higher rates of asthma and other respiratory illnesses. Additionally, changes in temperature and precipitation can exacerbate these conditions, leading to a cycle of health issues that further hinders physical development.

Nutritional status is another critical area impacted by climate change. As agricultural patterns shift due to changing climatic conditions, the availability of local food sources may decline, leading to food insecurity and poor nutritional outcomes. In mountainous regions, where access to diverse food options is already limited, these changes can result in higher rates of malnutrition among young people. Poor nutrition during critical growth periods can have long-lasting effects on physical development, including stunted growth, weakened immune systems, and cognitive impairments.

The psychological impacts of climate change should not be overlooked. Young people in mountainous regions may experience heightened anxiety and stress due to environmental changes, including natural disasters, loss of familiar landscapes, and uncertainty about the future. These psychological factors can contribute to mental health issues, which may further impede physical development. Creating supportive environments where young people can express their concerns and seek help is essential for addressing these challenges.

Addressing the impact of climate change on the physical development of young people requires comprehensive community engagement and policy interventions. Schools and local governments can play a crucial role by integrating climate education into curricula, raising awareness about the health implications of climate change, and promoting sustainable practices.

Programs that encourage physical activity in nature can help mitigate some of the health risks associated with climate change while promoting mental well-being. Initiatives that support local agriculture and food security can also improve nutrition, ensuring that young people have access to healthy foods that are essential for their growth and development.

Additionally, mental health support systems should be established to assist young people in coping with the stressors associated with climate change. This can include counseling services, community workshops, and youth-led initiatives aimed at fostering resilience and promoting mental health.

Further research is essential to deepen our understanding of the long-term effects of climate change on the physical development of young people in mountainous regions. Longitudinal studies can provide valuable insights into how changing climate patterns influence growth and health over time. Investigating the effectiveness of specific interventions aimed at mitigating these impacts will also be crucial for informing future policies and practices.

In conclusion, the physical development of young people in mountainous regions is intricately linked to the challenges posed by climate change. By recognizing the multifaceted nature of this issue, stakeholders can develop targeted strategies that address health implications, promote resilience, and support sustainable practices. Ensuring the well-being of young populations in vulnerable areas is not only vital for their individual health but also for the broader goal of fostering sustainable and healthy communities in the face of climate change.

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