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The Ecological Situation and Its Impact on the Health Status of the Children's Population of the Southern Aral Sea Region

N. P. Mirametova[1], S. M. Mambetullaeva[2], U. T. Azilova[1], E. T. Allamuratov[1], K. S. Abdullaev[1]

[1]Nukus State Pedagogical Institute, Uzbekistan
[2]Doctor of Biological Sciences, Karakalpak Scientific Research Institute of Natural Sciences, Uzbekistan

Abstract The article presents the results of a study of the features of the functional state of the cardiorespiratory system in children in the conditions of the South Aral Sea. The study of the patency of various sections of the tracheobronchial tree showed that in boys with age there is a tendency to increase bronchial patency. An increase in bronchial patency with the age of children with insignificant differences in the value of the vital capacity of the lungs can be attributed to the regional features of the external respiration system. It has been established that there is a relationship between physical development and functional characteristics of the circulatory system in children born and living in the South Aral Sea region. The data obtained suggest that the circulatory system in children is very sensitive to adverse environmental factors in the South Aral Sea region, thereby reducing their adaptive capacity and contributing to the formation of conditions for the development of diseases.

Keywords South Prearalie, Cardiorespiratory system, Child population, Physical development, External respiration, Blood circulation, Environmental factors

1. Introduction

The transformations of the ecosystem of the Aral Sea region, which occur as a result of a sharp change in the water regime, are numerous and varied. Under the conditions of the development of anthropogenic desertification processes, salts are removed from the dried bottom of the Aral Sea, degradation of the vegetation cover is observed, and the intensity of salt accumulation processes in the soil increases. On the dried bottom, new, shallow groundwater horizons are formed, with a high capillary rise of moisture and mineralization from 20 to 100 g/l. After the second year of drying the Aral Sea bottom, the coastal areas turn into plump salt marshes, the dryness and flowability of the soil increases. The resulting removal of salts to adjacent irrigated lands causes a significant decrease in crop yields [6].

The strategy of transforming the environment in order to satisfy a person's continuously growing needs, changing individual elements of the natural environment without taking into account the systemic organization of the relationship between nature and society, in general, led to changes in a number of certain parameters of the natural environment, which together reduce its quality and threaten the possibility of sustainable development [6].

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Environmental pollution is a complex and multifaceted problem. In the conditions of the drying up of the Aral Sea, this problem is exacerbated by the removal of toxic salts (sulphates and chlorides) from the dried bottom (Fig. 1). The dust-salt transfer factor (70 million tons/year) has become dominant in the deterioration of atmospheric air quality. Modeling of salt transfer from the post-aquatic land of the Aral Sea showed a multiple excess of MPC during salt and dust storms [4].

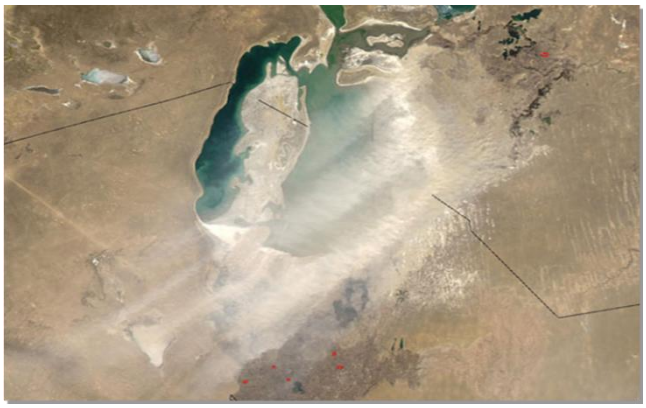

Figure 1. Wind removal of salts on March 15, 2002, = synthesized (1st-3rd channels) NOAA satellite image

The impact of salt aerosol from the post-aqueous land on the ecological situation in the southern Aral Sea region is not limited to soil salinization and vegetation degradation. As is

known, an increase in the concentration of aerosol in the air affects the kinetics and dynamics of atmospheric processes. The results of aerosol-radiation measurements [1], carried out in the Aral Sea region in 1979-1982 over the sea and the drained territory during salt-sand drifts showed significant changes in the distribution of the components of the radiation and hydrological balance of the "underlying surface – atmosphere" system.

Preservation of the adaptive potential of the organism under conditions of intense influence of various anthropogenic factors is one of the central problems of ecology and physiology. Individual adaptation is a process that develops in the course of life, as a result of which the body acquires resistance to environmental factors and is able to live in conditions previously unsuitable for life.

Currently, many researchers [1,2,10] have shown that, along with genetic factors, the development of the child's body is greatly influenced by environmental factors. The scientific significance of research on the problem of the physical development of children has especially increased in recent years [7,10,14]. The acceleration process has significantly slowed down or even stopped, and therefore there is a need for new scientific research. According to numerous data, indicators of physical development and health status of certain groups of the child population have acquired a negative trend over the past two decades [7,11,13]. At the same time, the specification of the situation in terms of timely and reliable information on the state of physical development of children and adolescents is constantly necessary for the organization of preventive work.

The functional features of the organism of children, who are still physiologically and mentally unformed and therefore most susceptible to various exogenous influences, are of great interest from an ecological and physiological point of view and are necessary for making a reasonable forecast for the functional reserves of the organism and the health of the population of the Republic of Karakalpakstan in the current environmental situation. The formation of the ecological situation in the South Aral Sea region could not but affect the functional state of the cardiorespiratory system.

2. Material and Methods

The surveyed contingent was a group of children aged 6 to 10 years. Geographically, all the subjects were divided into 3 groups in accordance with the place of permanent residence. The functional state of the children's body was assessed based on the results of a study of the function of external respiration (VC) by spirometry; cardiovascular system (heart rate, blood pressure). The functions of external respiration were studied by the method of pneumotachometry on the apparatus "Polyanalyzer - PA5-02". Assessment of the parameters of external respiration was carried out in a state of relative rest, in a sitting position. In the course of the study, the absolute values of external respiration indicators and their relationship to the average statistical norm, expressed as a percentage, were determined: FVC - vital capacity of the lungs (l); FEF 75 – patency of large bronchi (l/sec); FEF 50 - patency of the middle bronchi (l/sec); FEF 25 - patency of small bronchi (l/sec).

The evaluation of the results of the study and their mathematical processing were carried out according to the methods recommended in biological studies [9] and using the Microsoft Excel analysis package. Statistical methods used in the processing of the obtained material included determining the reliability of the obtained materials according to Student's t-test (the lower limit of significance was taken to be a significance level of 95% ($p < 0.05$)); conducting a correlation analysis of the indicators of the compared groups, with the determination of the correlation coefficient R by the Pearson method (significant correlation was considered when the coefficient was 0.7 or more) [9].

The analysis of the heart rate of children allows to determine the activity of the autonomic nervous system (ANS) in the implementation of the regulation of the cardiovascular system and to assess the degree of tension of the regulatory systems. The trend towards the growth of pathological deviations of blood pressure in children puts the problem of studying the circulatory system in a number of urgent problems of modern human physiology. Statistical analysis of heart rate is a research method recognized in applied and special physiology. It is based on the developments of R.M. Baevsky and others [3,5], which were originally intended to predict the state of a person in space flight, complex operator activities, etc. Currently, this method is used to determine the type of regulation of cardiac activity.

3. Results and Discussion

The respiratory system is a boundary system and is in direct contact with the external environment and one of the first to respond to changes in external conditions, pollution of the surface layer of air. The main purpose of respiration is the delivery of oxygen to the tissues and the removal of carbon dioxide formed as a result of oxidative processes. In accordance with the generally accepted concept of P.K. Anokhin's respiratory system is a complex of formations, including central (regulatory) and peripheral (perceiving) nervous components and working devices, functionally combined into a single system, the end effect of which is to maintain the relative constancy of the gas composition of blood and body tissues.

Studies of the function of external respiration provide essential information about the state of the adaptive mechanisms of the child's body. In response to a change in the quality of atmospheric air on the part of external respiration, first of all, bronchial patency changes. The level of bronchial patency is used to judge the state of adaptive changes. Such relative indicators as the vital capacity of the lungs, when assessing physical development, simultaneously characterize the functional capabilities of the organism

[6,11,15].

In the course of the study, we found that the child's body has two important periods in the development of the external respiratory system: at 6-7 years old, there is a significant decrease in bronchial resistance, which leads to an increase in the volume of inhalation and exhalation, and 8-10 years - a period of intensive increase in volume lungs. The general patterns of development of the functions of external respiration, its reserve and adaptive capabilities in the ontogeny of children have been comprehensively studied by specialists [1,2,5,6].

So, we note that according to experts, at the age of 8-12 years, there is a smooth maturation of the morphological structures of the lungs. However, between 8-9 years of life, the lengthening of the bronchial tree prevails over its expansion. As a result, the decrease in dynamic airway resistance slows down, and there is no dynamics of tracheobronchial resistance [2]. The greatest growth and development of the respiratory system occurs during puberty [5]. By the beginning of puberty, the total volume of the lungs increases 10 times, and by its ring - 20 times compared with those of a newborn. The cartilage of the bronchi in children is soft, flexible and easily springy. Elastic fibers are relatively poorly developed. The mucous membrane of the bronchi is rich in blood vessels, but relatively dry. According to N.A. Skoblina (2008), the final branching of the bronchial tree (segmental, subsegmental and terminal bronchi, bronchioles, alveolar ducts) ends by 7 years [13].

The results obtained on the functional indicators of the organism of children 6-10 years old indicate that in the process of development of children, the indicators of lung capacity (VC) tend to increase (Table 1). The vital capacity of the lungs in a child of 5-7 years old is 1200 ml in boys and 850 ml in girls. At 8-10 years old, this figure is 2000 ml and 1700 ml, respectively. [16]. So, in boys at the age of 6 and 7, the vital capacity (FVC) indicators were 1.90±0.07 l and 1.93±0.02 l, respectively. The greatest increase in FVC was observed in children aged 9 and 10; in boys, the FVC index was 2.18±0.08 and 2.34±0.07 l ($p<0.001$), respectively.

According to the analysis, it is observed that in girls aged 6 and 7 years, the FVC values were 1.60±0.04 and 1.62±0.08 liters, respectively. The greatest increase in FVC is observed in girls aged 9 and 10 years, the absolute values of FVC were 1.85±0.06 and 2.07±0.07 l ($p<0.001$), respectively. In girls aged 10, FVC was significantly higher - 2.07±0.07 l ($p<0.001$) than in girls aged 6 and not significantly higher than in girls aged 8 ($p>0.05$).

The study of the patency of various sections of the tracheobronchial tree showed that in boys with age there is a tendency to increase bronchial patency. In boys aged 9 and 10 years, the patency of the large bronchi (FEF-75) was 3.78±0.2 and 4.23±0.1 l/s, respectively, against 3.33±0.1 and 3.33±0.1 l/s ($p<0.001$) in boys aged 7 and 8 (respectively). In girls aged 9 and 10 years, the absolute values of FEF-75 were significantly increased to 4.31±0.2 l/s compared to 3.48±0.2 and 3.53±0.2 l/s, respectively, in girls 7 and 8 years ($p<0.001$).

The absolute index of middle bronchi patency (FEF-50) in boys aged 9 and 10 was significantly higher - 2.56±0.1 and 3.01±0.1 l/s, respectively, than in boys aged 7 and 8 ($p<0.001$) and 6 years ($p<0.01$). In girls, the FEF-50 mean bronchi index was 3.29±0.2 (10 years old) ($p<0.001$), 2.68±0.1 (9 years old) ($p<0.001$) and 2.36±0, respectively, 2 (6 years) ($p<0.05$).

It should be noted that the absolute parameters of the patency of small bronchi (FEF-25) in boys aged 9 and 10 years were also significantly higher, 1.33±0.07 and 1.54±0.1 l/s, respectively than in boys aged 6-8 years ($p<0.05$). As for girls, at the age of 9-10, the parameters of small bronchial patency (FEF-25) were significantly increased, respectively, to 1.42±0.1 and 1.76±0.01 l/s ($p<0.001$) than in girls aged 7-8 years and significantly against 1.23±0.1 l/s in girls aged 6 years ($p<0.001$). The absolute indicators of maximum expiratory flow rate (PEF) in boys increased with age. The greatest increase in PEF was observed in boys aged 9 and 10 years, respectively, 4.49±0.2 and 4.91±0.2 l/s versus 3.25±0.1 and 3.77±0.1 l/s at ages 7 and 8, respectively. A significant increase in the absolute PEF was observed in girls aged 9 and 10 (4.24±0.1 and 5.17±0.1 l/s, respectively) ($p<0.01$).

Table 1. Age dynamics of external respiration functions indicator in children living in the South Aral Sea region (M+m)

age	gender	FVC	PEF	FEF-75	FEF-50	FEF-25
6	B	1,90±0,07	3,11±0,1	3,28±0,1	2,40±0,1	1,16±0,03
	G	1,60±0,04	3,76±0,2	3,34±0,2	2,36±0,2	1,23±0,1
7	B	1,93±0,02	3,25±0,1	3,39±0,1	2,47±0,1	1,24±0,02
	G	1,62±0,08	3,86±0,2	3,48±0,2	2,49±0,2	1,31±0,1
8	B	1,94±0,08	3,77±0,1	3,33±0,1	2,50±0,1	1,26±0,07
	G	1,72±0,08	4,06±0,2	3,53±0,2	2,54±0,2	1,36±0,1
9	B	2,18±0,08	4,49±0,2	3,78±0,2	2,56±0,1	1,33±0,07
	G	1,85±0,06	4,24±0,1	3,86±0,1	2,68±0,1	1,42±0,1
10	B	2,34±0,07	4,91±0,2	4,23±0,1	3,01±0,1	1,54±0,1
	G	2,07±0,07	5,17±0,1	4,31±0,2	3,29±0,2	1,76±0,01

Note: G - girls, B - boys, FVC - vital capacity (l); FEF 75 – patency of large bronchi (l/sec); FEF 50 - patency of the middle bronchi (l/sec); FEF 25 - patency of small bronchi (l / s), PEF - maximum expiratory flow (l / s).

Conducted studies by the method of pneumotachography in the examined children revealed the following results. It was shown that in boys aged 6 - 7 years, the vital capacity of the lungs averaged 1.90±0.07 l, which corresponds to 92% of the proper values. The values of VC in boys aged 8-10 years were significantly lower ($p<0.05$) than the proper values of this indicator for persons of the corresponding sex and age (8-10 years). In girls aged 6 and 7 years, VC was reduced relative to the expected values (86%) and more pronounced than in boys, which is statistically significant ($p<0.05$).

On the basis of the provisions of the theory of adaptation and functional systems, it can be considered that different levels of functioning of the body correspond to states that are not the same in terms of severity. There is also a different degree of tension of compensatory mechanisms. All this is reflected in the mathematical indicators of sinus heart rate, which was the basis for the cardiointervalographic characteristics of the severity of the condition in various pathologies (neurocirculatory dystonia, rhythm and conduction disturbances, hypertension) and as a predisposing factor (atherosclerosis, coronary heart disease) in children.

For each age period, it is necessary to have a clear idea of the indicators of cardiointervalograms of healthy children of different age groups. It is known that each age period of childhood is characterized by anatomical and physiological features, which are also reflected in the sinus heart rate. Based on the analysis of the structure of the sinus heart rate, it seems possible to obtain information about the current interaction of the links in the control of the activity of the heart, to judge the nature of the protective and adaptive reactions of the body. In other words, indicators reflecting the nature of the sinus heart rate can be considered as integral parameters of reactivity, first of all, of autonomic homeokinesis, as one of its most important links.

4. Conclusions

The general trend demonstrates the relative stabilization of age-related changes in R-R in both boys and girls. At the same time, the gradient of change in R-R intervals in girls was lower than this indicator than in boys (R-R gradient for girls - 0.05 sec, boys - 0.09 sec), by almost 50%, and the gradients of changes in cardiorhythmogram parameters prevailed in boys. However, taking into account the high pollution of the surface layer of the atmosphere in the South Aral Sea region, an increase in bronchial patency detected in children was regarded by us as an undesirable reaction and one of the factors contributing to the development of bronchopulmonary pathology. An increase in the patency of the bronchi in the conditions of dustiness of the surface layer of air is physiologically irrational. The persistence of this reaction in the future can lead to various pathological changes in the bronchopulmonary apparatus, which partly explains the growth of bronchopulmonary pathology in the children's population in the South Aral Sea region.

The data obtained are consistent with the results of a study by specialists and suggest that the circulatory system in children is very sensitive to adverse environmental factors in the South Aral Sea region, thereby reducing their adaptive capabilities and contributing to the formation of conditions for the development of diseases.

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