

¹Ongarbaeva D.T., ¹Kurmanaliyev S.K., ^{1*}Krugovykh I.,
¹Degert N., ²Sagot J.

¹al-Farabi Kazakh National University, Almaty, Kazakhstan

²Paris 8 University, Paris, France

*e-mail: ilya_krugovykh@mail.ru

Study of the functional state of cardiorespiratory system of students of the al-Farabi Kazakh National University

Abstract. Integration of the national higher education system of Kazakhstan into the international education puts forward increased requirements for the training of specialists whose quality is determined by the level of physical health of students. In the conditions of modernization, today's student's educational activity characterized by saturation, intensity, high level of psychoemotional tension and complexity which is carried out against a background of decreased motor activity and physical health [1, 2, 3, 4]. Therefore, today in the system of higher education of our Republic there is a contradiction between the need to improve the quality of education and the lack of physical health of future specialists. The universities face a problem when a future specialist with insufficient physical health is not quite ready for the tough demands of the modern labor market. The preparation of highly qualified and competitive new generation specialists who is capable of adapting to rapidly changing social and economic conditions is impossible without good health. There we find out that the one of the most important conditions for the disclosure of student labor potential is the strengthening and preservation of their health [5]. One of the main factors determining the level of physical health of student is the functional state of a vital cardiorespiratory system that combines external breath, heart and hemodynamics.

This article presents the results of a study of the functional readiness of the cardiovascular and respiratory systems of students of the KazNU named al-Farabi, who studies in the academic lessons of physical education in the main educational department.

Key words: functional state, cardiorespiratory system.

Introduction

The physical health of a person is determined by a complex of interrelated factors, where the functional state of external respiration and the cardiovascular system plays an important role. They are the main systems of the oxygen transportation system, which provide the body with oxygen [6].

The cardiovascular system is a system of organs that together provide circulation of blood in the human body and provide its homeostasis [7; 8].

The functions of the cardiovascular system are very global and are important for the human body as a whole: it is fully responsible for the process of blood circulation in the body and for the enrichment of all cells of the body with the necessary minerals, vitamins, and oxygen (O₂). Reserve of CO₂ (carbon dioxide), organic and inorganic substances worked out by the body, is also carried out with the help of the cardiovascular system.

The lymphatic system, being an auxiliary mechanism of the cardiovascular system, supplements the movement of fluid (lymph) in the human body.

The human respiratory system is a set of organs that provide the human body with oxygen (an important chemical element involved in oxidation-reduction processes) [9; 10].

Normal and full-fledged functioning of all organs and systems of the human body can be achieved only if the energy balance is quickly and timely restored. The organism is supplied with energy due to oxidation of the basic organic substrates – carbohydrates, fats, proteins.

Thus, it can be stated that the activity of all body structures, beginning with the cell and ending with the system of organs, is coordinated and subordinated to a single whole. Each structural unit contributes to the functioning of the body.

The functional state of the cardiorespiratory system is one of the main factors that have the greatest impact on a person's physical health.

At the same time, the functional readiness of the studying system of human, reflecting the level of functioning of the cardiovascular and respiratory system comes as a result of physical training, which is carried out in the process of exercising.

Materials and methods

To study the function of external respiration of students (21 men and 27 girls) of Al-Farabi KazNU, we used the method of *spirometry* using the spirometer "BTL-08 SpiroPro" which measures and records on paper the following basic parameters of respiration [11-13]:

- ERV and IRV (ml);
- VC (ml);
- LI (life index);
- FVC (ml);
- FEV₁ (ml);
- FEV₁ / FVC (%);
- PEF (l/s);
- FEF₂₅, FEF₅₀, FEFC₇₅ (l/s);
- MVV (l/min).

Complex evaluation of the cardiovascular system of the surveyed contingent was carried out according to indicators:

- heart rate (HR), systolic (SBP) and diastolic blood pressure (DBP) in a state of relative dormancy with the calculation of Kvass indices, cost-effectiveness factors and self-regulation of blood circulation [14; 15];

- reactions of cardiovascular system for standard physical activity – a functional test of Martine-Kushelovsky [16; 17].

To prove objectivity and reliability, the results were processed in the computer program "Excel" with the calculation of the following statistical characteristics: arithmetic mean, average squared difference and coefficient of variation [18; 19].

Results and discussion

Assessment of the external respiration state of the surveyed contingent was carried out using the methodology of RF. Clement [20], based on age and height. The average age-growth indicators of our surveyed students are: 18.5 years and 172.1 cm in boys; 17.5 years and 161.7 cm in girls.

The results of the study of the state of external respiration of students (boys and girls) are shown in tables 1, 2.

Table 1 – Results of the study of the state of external respiration of young men of the basic educational department of KazNU named al-Farabi

Indicators	Actual average ($\bar{x} \pm \sigma$)	Factor of variation of actual indicators (V, %)	Due average (by Clement) ($\bar{x} \pm \sigma$)	Deviation of actual averages from due average in %
IRV (ml)	2320 ± 350	10.5	2634.5 ± 350	- 11.9
ERV (ml)	1560 ± 120	10.8	1676.0 ± 120	- 6.9
VC (ml)	4790 ± 490	10.2	4670 ± 297	+ 2.5
LI	77.2 ± 5.5	7.1	67.5 ± 2.5	+ 14.4
FVC (ml)	4790 ± 518	10.4	4530 ± 297	+ 5.7
FEV ₁ (ml)	4470 ± 717	16.0	3960 ± 221	+ 12.9
FEV ₁ / FVC (%) Gensler's Index	83.58 ± 7.0	8.4	87.5 ± 2.5	- 4.5
PEF (l/s)	9.66 ± 1.63	17.0	8.46 ± 0.6	+ 14.2
FEF ₂₅ (l/s)	3.10 ± 1.21	39.2	2.67 ± 0.1	+ 16.1
FEF ₅₀ (l/s)	5.96 ± 2.0	33.7	5.55 ± 0.4	+ 7.4
FEF ₇₅ (l/s)	8.64 ± 2.08	24.2	8.28 ± 0.8	+ 4.3
MVV (l/min)	107.0 ± 22.2	20.7	106.5 ± 8.1	+ 0.5

Analyzing the average statistics of external respiration according to Table 1, we can say the following:

– IRV reduced by 11.9%, and ERV by 6.9%; LI and VC exceed the required norms by 14.4% and 2.5%, respectively;

– FVC is higher than the required regulatory requirements by 5.7%;

– FEV₁ is above the standards by 12.9%; the Gensler's index is only slightly reduced by 4.5%;

– PEF is more than normal by 14.2%; FEF₂₅, FEF₅₀ and FEF₇₅ increased by 16.1, 7.4 and 4.3 percent respectively;

– MVV is slightly higher than due norms (0.5%).

Table 2 – Results of the study of the state of external respiration of girls in the main educational department of KazNU named al-Farabi

Indicators	Actual average ($\bar{x} \pm \sigma$)	Factor of variation of actual indicators (V, %)	Due average (by Clement) ($\bar{x} \pm \sigma$)	Deviation of actual averages from due average in %
IRV (ml)	1760.8 ± 284.6	24.5	1931.3 ± 101.1	- 8.8
ERV (ml)	868.9 ± 257.5	45.3	965.7 ± 50.5	- 10.0
VC (ml)	3836.8 ± 447.2	18.4	3511.5 ± 183.7	+ 8.5
LI	54.5 ± 6.4	14.4	57.5 ± 2.5	- 5,2
FVC (ml)	3717.7 ± 555.6	26.2	3441.2 ± 170.5	+ 8.0
FEV ₁ (ml)	3139.4 ± 393.0	20.2	3057.3 ± 129.5	+ 2.7
FEV ₁ / FVC (%) Gensler's Index	81.1 ± 19.6	24.1	90.0 ± 5	- 9.8
PEF (l/s)	7.6 ± 0.9	24.1	6.7 ± 0.2	+ 13.4
FEF ₂₅ (l/s)	6.4 ± 0.9	25.1	6.1 ± 0.2	+ 4.9
FEF ₅₀ (l/s)	4.7 ± 1.0	36.4	4.6 ± 0.2	+ 2.2
FEF ₇₅ (l/s)	2.7 ± 0.8	40.9	2.4 ± 0.1	+ 12.5
MVV (l/min)	59.2 ± 12.0	20.2	82.5 ± 4.0	- 28.2

Analyzing table 2, we can state that the average statistical indicators for girls are as follows:

– IRV is reduced by 8.8%, and ERV by 10.0%; LI is reduced from the due norms by 5.2%, while the VC is higher than the standards by 8.5%;

– FVC is higher than the corresponding regulatory requirements by 8.0%;

– FEV₁ is also above the norm by 2.7%; the Gensler's index is only reduced by 9.8%;

– PEF is higher than the established rate by 13.4%; FEF₂₅, FEF₅₀ and FEF₇₅ also exceed them by 4.9; 2.2 and 12.5 percent respectively;

– MVV is below the due standards (28.2%).

The parameters of the functional state of the cardiovascular system at rest of the surveyed contingent are presented in Table 3.

Analyzing the functional parameters of the cardiovascular system in the students of the main educational department at rest, it can be noted that:

– HR, SBP, DBP and PP parameters correspond to the due norms of sex and age, both in girls and boys, but the pulse and its pressure are at the upper limit of the norm;

– TSBC equal to 93.6 in girls and 94.7 in boys, is characterized as a cardiovascular type, also within the proper norms;

– CEBC, exceeding the upper limit of the norm, indicates the initial stage of the state of fatigue;

– EF according to the Kvass formula, above the due norms, which indicates the weakening of the cardiovascular system and the reduction of the aerobic mechanism of energy supply of the body.

Table 3 – Average statistical indicators of the functional state of the cardiovascular system at rest in students of the main educational department of KazNU named al-Farabi

Indicators	Girls	Boys	Estimated rate	
	M ± σ	M ± σ	Lower bound	Upper bound
Systolic blood pressure (SBP), mmHg	117.0 ± 9.9	119.1 ± 9.4	110	126
Diastolic blood pressure (DBP), mmHg	76.5 ± 6.8	73.9 ± 6.4	60	80
Pulse pressure (PP), mmHg	40.5 ± 10.1	37.4 ± 12.6	35	40
Heart rate (HR), beats / min	79.8 ± 13.1	78.6 ± 7.8	60	80
Type of self-regulation of blood circulation (TSBC)	93.6 ± 19.1	94.7 ± 13.5	90	110
The coefficient of efficiency of blood circulation (CEBC)	3104.9 ± 1095.2	3390.4 ± 1077.0	2500	3000
Endurance factor (EF)	21.0 ± 6.1	19.6 ± 7.5	16	

Thus, by systematizing the obtained average statistical results of the cardiorespiratory system research in a state of relative rest in the surveyed contingent, it can be concluded that:

- all indicators of young male correspond to the age-sex physiological norms, exception: endurance factor, blood circulation economy index (CEBC), reserve volumes of breath in and out (IRV, ERV), which indicates a weakening of the heart and characterizes unreadiness of their respiratory system for physical exertion;

- almost all major girls indicators of external respiration also within the proper standards, exception inspiratory and expiratory reserve volumes (IRV, ERV), the life index (LI), the index of Gensler and

maximum ventilation indicators of lungs (MVV), which doesn't correspond to standards and shows the weakness of their breathing apparatus for physical activity. The research of the cardiovascular system shows that in a state of relative rest the functional state of students fit properly in age-sexual norms, except of profitability ratios circulation (PRC) and endurance factor (EF).

Due to the fact that the above mentioned results indicate the insufficient readiness of the cardiorespiratory system of young people for physical activity, we evaluated its response to the standard physical load in the form of a Martine-Kushelovsky functional test (20 sit-ups in 30 seconds), the results of which are shown in Table 4.

Table 4 – Average rates of cardiovascular system reaction of students of KazNU named after Al-Farabi for the Martine-Kushelovsky trial

At rest			Recovery period					
			1 minute		2 minutes		3 minutes	
	HR	AP	HR	AP	HR	AP	HR	AP
Girls	75	117/77	136	126/77	109	122/75	90	116/72
Boys	72,3	112/74	135	122/63	109	120/64	98	115/64

Based on the analysis of cardiovascular system reaction of the students right after the exercise (the first minute of recovery) in comparison with the baseline, we can say:

– the systolic pressure rises weakly, which is 3-4 times lower than the norm; it reflects the weakening of the systole force – the contraction of the left heart of the heart;

– the diastolic pressure of the girls remains unchanged, indicating a decrease in the tone of the arterioles, which ensures better access of oxygen to the periphery, while in young men, having a tendency to a sharp decrease, contributes significantly higher than the required standards to a rise in pulse pressure;

– a significant increase in heart rate, indicates that the increase in blood circulation, even with a low-intensity load, is achieved by increasing the heart rate, and not increasing the stroke volume of the heart, which is irrational for the heart.

– The AP on the third minute of rest is restored to the initial value, and the period of recovery of heart rate is delayed.

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Thus, on the basis of a generalization of the results of our study, we can briefly summarize:

– in rest the functional state of the cardiovascular system of practically healthy students corresponds to the proper age and sex standards;

– for standard physical activity, the cardiovascular system in both boys and girls reacts with a significant increase in heart rate, a slight increase in systolic and unchanged diastolic pressure in girls but decrease DP in boys, an increase in the recovery time of heart rate, which can be characterized as unfavorable – asthenic (hypotonic) type of reaction.

All this testifies to the physical detraining of the body of students and justifies the actual need for the development, scientific and methodological substantiation and introduction of the most rational methods and means of physical training that have the greatest health and training effect into the practice of physical education.

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