

# Analysis of Changes in Indicators of Physical Health of Ukrainian Students after the End of Quarantine Restrictions COVID-19

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**Abstract** Quarantine restrictions of COVID-19 and the transition to distance learning have significantly affected the ability of teachers to conduct physical education classes and develop functional and motor abilities of students. Establishing the state of physical health of students allows the teacher to systematize the received information and, based on it, make a choice of forms, methods and means of physical education. 889 students aged 17-19, who studied for the 1st year at Khmelnytskyi Humanitarian-Pedagogical Academy (697 women and 192 men) took part in the research. The goal is to conduct a comparative analysis of changes in physical health indicators of students after the end of the quarantine of COVID-19. Methods: analysis of scientific and methodological sources; survey; pedagogical observation; methods of studying the functional state of students; comparative analysis; methods of mathematical statistics. Results: women showed the following changes: increase in body weight (BW) +4.09%;

increase in chest girth (ChG) +5.2%; decreased vital capacity of the lungs (VC) -4.51%; deterioration of the life index (LI) -8.77%; deterioration of the index of the reserve and the efficiency of the cardiovascular system (IR) +5.81%; increase in the rate of recovery of the cardiovascular system after physical exertion (RI) +7.93%. Men showed: increase in body weight (BW) +3.71%; increase in chest girth (ChG) +3.22%; decreased vital capacity of the lungs (VC) -3.36%; deterioration of the life index (LI) -6.84%; deterioration of the index of the reserve and the efficiency of the cardiovascular system (IR) +6.88%; increase in the rate of recovery of the cardiovascular system after physical exertion (RI) +7.31%. Conclusions: the comprehensive comparative analysis of the average statistical indicators of young people's state of health showed anthropometric, functional and morphofunctional changes in students' state of health, which indicate the appearance of excess weight, the

deterioration of indicators of the work of the cardiovascular and respiratory systems, and as a result – decrease in the energetic potential of working capacity of girls and boys.

**Keywords** Physical Education, Physical Activity, Quarantine Restrictions, Indicators of Physical Health, Students

## 1. Introduction

Motor activity of people is one of the main factors that determine the level of their physical health and work capacity. Quarantine restrictions introduced in Ukraine, in connection with the spread of the COVID-19 pandemic and the transition to distance education of pupils and students led to the undesirable effect – sharp decrease in the motor activity of young people, which could not but affect the state of their physical health [1, 2]. The level of human health depends 50% on the conditions and lifestyle [3]. Severe restrictions on the movement and communication of students at the first stage of the pandemic caused a negative impact on the psychological and emotional perception of reality and introduced innovations in the organization of the educational process. Due to the lack of live communication with peers and the impossibility of engaging in favorite types of motor activity in everyday life, it led to the appearance of depressive states of some young people and was reflected in the change from an active lifestyle to a sedentary one [4, 5]. During the period of quarantine restrictions, the majority of students spent their free time visiting various sites on the Internet, which contributed to the transition to the sedentary lifestyle.

Specialists in physical culture and sports in Ukraine during the transition to distance learning tried to develop and implement various programs for the physical improvement of young people in the educational process. As a rule, the basis of these programs was various fitness programs that can be used at home during distance learning [6-9]. The implemented distance learning programs in physical education only partially solved the problems of compensating for the low motor activity of young people and contributed to the development of certain physical qualities. The main drawback of fitness programs was the impossibility of a comprehensive solution to the problem of developing physical qualities and compensating for the lack of motor activity of students. The main problem of distance learning, during the quarantine restrictions, was the impossibility of fully filling the educational process with physical education [10, 11]. Namely: conducting classes on game sports, participation of students in mass sports-recreation and entertainment events, limited opportunity to participate in sports competitions and support their favorite teams [12].

Analysis of modern scientific researches shows that motor activity is an integral part of every person's behavior.

It affects the normal functioning of the body's systems and the preservation of health. Insufficient motor activity of students leads to the increase in the level of morbidity, the appearance of disorders during the development of a young person's body, and the decrease in adaptation capabilities [13, 14]. Successful solving of learning tasks is inextricably linked to monitoring the level of physical health of students [15, 16]. The teacher can obtain such information based on the results of the medical examination of students and the monitoring of the initial level of physical fitness [17, 18].

For the first time, higher educational institutions of Ukraine faced the situation of the forced transition to distance education, which lasted for more than two years. Quarantine restrictions of COVID-19 and the transition to distance learning have significantly affected the ability of teachers to conduct physical education classes and develop functional and motor abilities of students. The low level of motor activity of students during distance learning definitely affected the functional and morphofunctional indicators of students' health. That is why it is important to monitor the state of the physical health of students after two years of distance learning and perform comparative analysis with the indicators of physical health of students before the introduction of quarantine restrictions. Establishing the state of physical health of students allows the teacher to systematize the received information and, based on it, make a choice of forms, methods and means of physical education [19, 20]. Before the start of quarantine restrictions of COVID-19, scientists paid attention to the deterioration of physical health indicators of students [7, 21].

Therefore, in our opinion, for a holistic understanding of the processes that affect the state of physical health of students, it is necessary to study the dynamics of functional and morphofunctional changes five years before the beginning of the quarantine restrictions of COVID-19 and after the end of the quarantine.

*The objective of the research* is to conduct comparative analysis of changes in the physical health indicators of students after the end of the quarantine of COVID-19.

## 2. Materials & Methods

### The participants of the experiment

889 students aged 17-19, who studied in the 1<sup>st</sup> year of Khmelnytskyi Humanitarian-Pedagogical Academy (697 women and 192 men). All participants of the research underwent medical examination and had no deviations in physical health indicators and were included in the main medical group.

### Procedure

The conducted research included the following stages:

1. At the beginning of the study. Establishing indicators of physical health of students enrolled in the first year of study in 2016 (192 women and 52 men);
2. Phase 1. Establishing indicators of physical health of students enrolled in the first year of study in 2018 (178 women and 48 men), and carrying out comparative analysis with indicators of students in 2016.
3. Phase 2. Establishing indicators of physical health of students enrolled in the first year of study in 2020 (166 women and 47 men), and carrying out comparative analysis with indicators of students in 2016. Establishing changes in physical health indicators of students before the start of quarantine restrictions.
4. Phase 3. Establishing indicators of physical health of students enrolled in the first year of study in 2023 (161 women and 45 men), and carrying out comparative analysis with indicators of students in 2016 and 2020. Determining changes in the indicators of physical health of students after the end of quarantine restrictions COVID-19.
5. Statistical analysis of the impact of quarantine restrictions of COVID-19 on indicators of the state of physical health of students.

## Methods

To obtain the necessary information, we used the following research methods: analysis of scientific and methodological sources; questionnaire; survey; pedagogical observation; methods of studying the functional state of female students; comparative analysis; methods of mathematical statistics.

We used the analysis of scientific and methodological sources to study the problem of conducting physical education classes for young people after illnesses and long breaks in physical activity. Surveys and questionnaires were conducted during the determination of well-being and identification of deviations in the state of health of female students. Pedagogical observation was carried out as a systematic analysis of the assessment of the individual physical development of female students and the establishment of changes in their morphofunctional state. Determining the level of anthropometric, indicators of physical development of girls included obtaining the following results: body length (BL); body weight (BW); chest girth (ChG). The study of functional indicators included determination of: heart rate at rest (HR); systolic blood pressure (SBP); diastolic blood pressure (DBP); pulse pressure (PP); vital capacity of lungs (VC). During the morphofunctional testing of female students, we obtained the following data: body mass index (BMI), life index (LI), human energy potential index (IR), endurance index (CV), Ruffier index (RI).

Body mass index (BMI) was determined by the formula:

$$BMI = BW / BL^2$$

Where:

BMI - body mass index;  
 BW - body weight in kilograms;  
 BL - body length in meters.

Life index (LI) was determined by the formula:

$$LI = VC / BW$$

Where:

LI - life index;  
 VC - indicator of the vital capacity of lungs;  
 BW - body weight.

Human energy potential index (IR) was determined by the formula:

$$IR = (HR \times SBP) / 100$$

Where:

IR - Robinson index;  
 HR - heart rate at rest;  
 SBP - systolic blood pressure.

Endurance index (CV) was determined by the formula A.Kvass:

$$CV = HR \times 10 / PP$$

Where:

CV - endurance index;  
 HR - heart rate at rest;  
 PP - pulse pressure.

Ruffier index (RI) was determined by the formula:

$$RI = (4 \times (P1 + P2 + P3) - 200) / 10$$

Performing the Ruffier test requires compliance with certain conditions: after a five-minute calm state in a sitting position, count the pulse for 15 seconds (P1), then perform 30 squats within 45 seconds. Immediately after that, count the heart rate for the first 15 seconds (P2) and the last 15 seconds (P3) of the first minute of the recovery period.

The comparative analysis was carried out in order to determine the level of physical health and changes in the morphofunctional indicators of female students, which were caused by the sedentary lifestyle during the period of quarantine restrictions of COVID-19. The methods of mathematical statistics were used to reliably determine the indicators of the morphofunctional capabilities of female students and to determine their state of health.

## Ethics

This research complies with the ethical standards of the Act of Ukraine "On Higher Education" No. 1556-VII dated 01.07.2014 and the Letter from the Ministry of Education and Science of Ukraine "On the Academic Plagiarism Prevention" No. 1/11-8681 dated 15.08.2018. Also, this research followed the regulations of the World Medical Association Declaration of Helsinki – ethical principles for medical research involving human subjects. In accordance

with ethical standards, students participated in the study voluntarily with written consent.

### 3. Results

Indicators of body weight, height and body composition of students largely determine the level of their health. Anthropometric measurements help to track the dynamics of students' physical development. Studies of indicators of

physical development of students based on anthropometric measurements of body length (BL); body weight (BW); chest girth (ChG) are presented in Table 1. Determining the functional indicators of the physical condition of students who entered the first year of study at Khmelnytskyi Humanitarian-Pedagogical Academy included the analysis of the following indicators: heart rate at rest (HR); systolic blood pressure (SBP); diastolic blood pressure (DBP); pulse pressure (PP); the vital capacity of lungs (VC), which are presented in Table 1.

**Table 1.** Indicators of anthropometric and functional condition of students at different stages of the research ( $X \pm m$ )

Indicators	Research phases						
	At the beginning of the study	Phase 1	Phase 2	Changes	Phase 3	General changes	Changes %
<b>Group of girls (n = 697)</b>							
BL (cm)	162.8 ± 9.0	163.2 ± 9.5	163.4 ± 9.5	+0.6 ± 0.5	163.6 ± 10.0	+0.8 ± 1.0	+0.49
BW (kg)	56.2 ± 7.6	56.8 ± 7.2	57.4 ± 6.7	+1.2 ± 0.9	58.5 ± 8.0	+2.3 ± 0.4	+4.09
ChG (cm)	86.5 ± 7.5	87.0 ± 8.0	88.5 ± 8.0	+2.0 ± 0.5	91.0 ± 7.0	+4.5 ± 0.5	+5.20
HR (bt/min)	80.6 ± 7.0	81.0 ± 7.5	81.5 ± 7.6	+0.9 ± 0.6	82.8 ± 8.0	+2.2 ± 1.0	+2.73
VC (ml)	2880 ± 80	2850 ± 100	2830 ± 100	-50 ± 20	2750 ± 120	-130 ± 40	-4.51
Systolic SBP (mmHg)	116.5 ± 8.0	116.5 ± 10.0	117.0 ± 9.0	+0.5 ± 1.0	120.0 ± 9.0	+3.0 ± 1.0	+3.49
Diastolic DBP (mmHg)	75.0 ± 7.0	75.5 ± 7.5	75.0 ± 6.0	-	77.5 ± 7.0	+1.0 ± 1.0	+3.33
PP (mmHg)	41.5 ± 3.5	42.0 ± 3.0	42.0 ± 3.0	+0.5 ± 0.5	42.5 ± 3.5	+1.0 ± 0.5	+2.41
<b>Group of boys (n = 192)</b>							
BL (cm)	174.8 ± 7.5	175.2 ± 8.4	175.4 ± 8.2	+1.0 ± 0.7	175.6 ± 8.2	+1.2 ± 0.7	+0.46
BW (kg)	67.3 ± 6.3	67.5 ± 8.0	68.1 ± 6.6	+0.8 ± 0.3	69.8 ± 7.2	+2.5 ± 0.9	+3.71
ChG (cm)	93.0 ± 7.5	94.0 ± 8.0	94.0 ± 8.0	+1.0 ± 0.5	96.0 ± 8.0	+3.0 ± 0.5	+3.22
HR (bt/min)	74.5 ± 6.5	75.0 ± 7.5	75.3 ± 7.0	+0.8 ± 0.5	76.7 ± 7.5	+2.2 ± 1.0	+2.95
VC (ml)	3570 ± 170	3550 ± 150	3520 ± 150	-50 ± 20	3450 ± 150	-120 ± 20	-3.36
Systolic SBP (mmHg)	117.5 ± 6.5	118.0 ± 6.0	119.0 ± 7.0	+1.5 ± 0.5	122.0 ± 7.0	+4.5 ± 0.5	+3.83
Diastolic DBP (mmHg)	75.0 ± 5.0	75.0 ± 6.0	75.5 ± 5.5	+0.5 ± 0.5	78.0 ± 7.5	+3.0 ± 0.5	+4.00
PP (mmHg)	42.5 ± 3.5	43.0 ± 3.0	43.5 ± 3.0	+1.0 ± 0.5	44.0 ± 4.0	+1.5 ± 0.5	+3.53

Comparative analysis of changes in anthropometric indicators of girls made it possible to determine the main trends in their physical development. A gradual increase in body weight and chest girth of girls is observed. This fact was pointed out by various groups of researchers [22, 23]. The average statistical indicator of body weight growth of girls who entered the first year of study for the period 2016-2020 was +2.14% ( $p < 0.05$ ), and for two years of quarantine restrictions this indicator was +4.09% ( $p < 0.05$ ) as seen in Table 1. Similar trends are observed with changes in chest girth indicators. The increase in indicators for the period 2016-2020 was +2.31% ( $p < 0.05$ ), and for two years of quarantine restrictions +5.2% ( $p < 0.05$ ).

Men showed similar dynamics of changes in anthropometric parameters. Students who entered the first course of study in the period 2016-2020, had the change in body weight index of +1.19% ( $p > 0.05$ ), and after the end of the quarantine COVID-19 +3.71% ( $p < 0.05$ ); the change in the index of chest girth for the period 2016-2020 was +1.08 ( $p > 0.05$ ), and during the period of quarantine restrictions +3.22 ( $p > 0.05$ ). We believe that the insufficient level of physical activity of students and their sedentary lifestyle accelerated the processes of body weight growth and chest girth increase of women and men, which occurred with almost unchanged body length indicators. These changes in anthropometric indicators are reflected in negative changes in the body proportions of students.

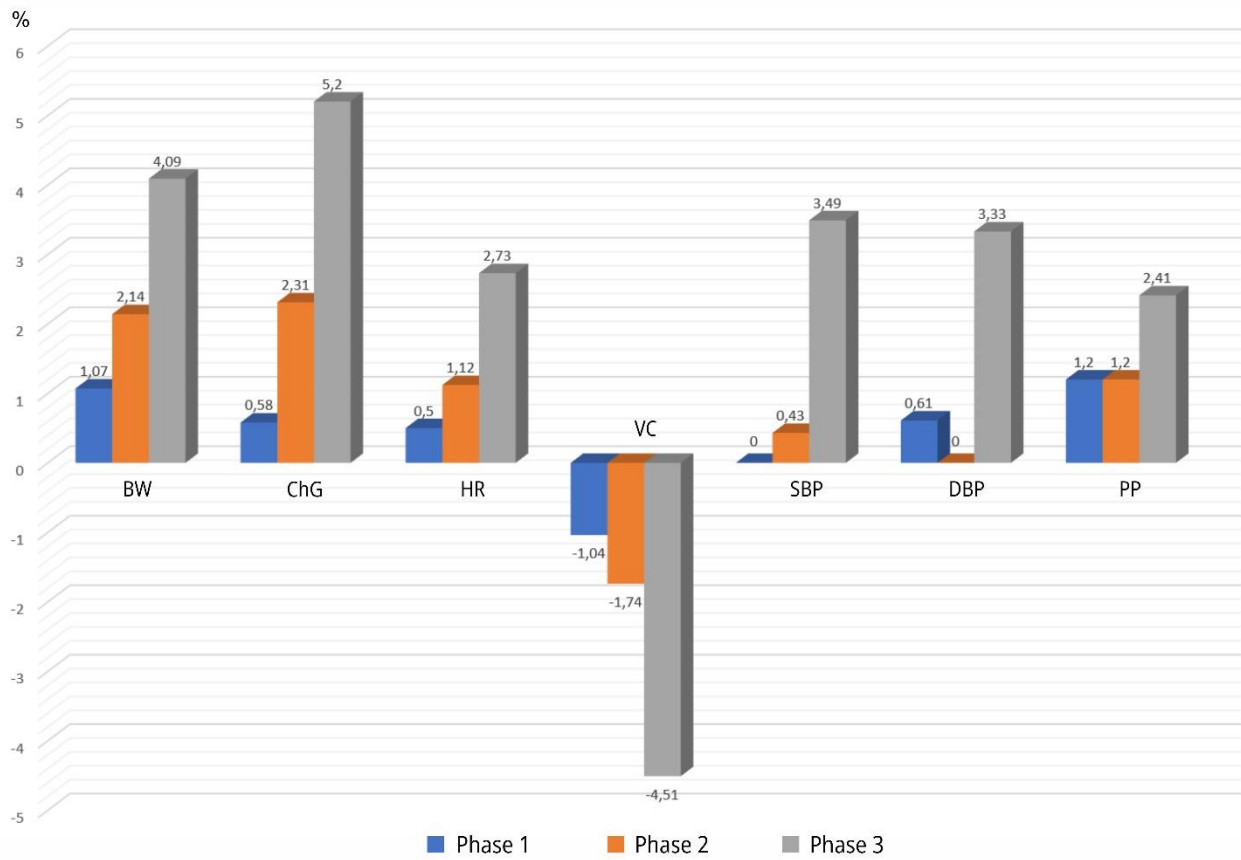
Determining the functional indicators of the physical condition of students who entered the first year of study of Khmelnytskyi Humanitarian-Pedagogical Academy included the analysis of the following indicators: heart rate at rest (HR); systolic blood pressure (SBP); diastolic blood pressure (DBP); pulse pressure (PP); the vital capacity of lungs (VC), which are presented in Table 1.

Many factors affect heart rate at rest (HR), the main ones being: regular sports, overeating, bad habits, sedentary lifestyle, and stressful situations. During the period of

quarantine restrictions, these factors had a direct impact on the organization of everyday life of students. The results of our research showed that the HR indicators are within the age-related development of students, but had a negative upward trend. For five years of research before the start of quarantine restrictions, the growth of HR indicators was +1.12% ( $p > 0.05$ ), and for two years of distance learning, the growth of HR was +2.73% ( $p > 0.05$ ) see Table 1. This fact indicates the tendency to decrease the level of training and decrease the level of functional capabilities of the circulatory system as a result of the sedentary lifestyle of female students during the quarantine restrictions.

The results of our research showed that the SBP and DBP indicators of girls of the first year of study fluctuated within the age norm of functional development and during the years 2016-2020 did not undergo statistically significant changes. In 2023, there is an increase in the SBP indicator by +3.49% ( $p > 0.05$ ); DBP +3.33% ( $p > 0.05$ ). At the same time, there is the increase in the number of female students who had significant deviations of SBP and DBP indicators from the average statistical values.

The analysis of indicators of vital capacity of lungs (VC) of female students who entered the first year of study showed a general trend towards the appearance of a larger number of girls whose indicator does not correspond to the norms of age-related development. The comparative analysis of the average of the statistical indicators of VC indicates its decrease by -1.74% ( $p > 0.05$ ) in 2020 and by -4.51% ( $p < 0.05$ ) in 2023 compared to the indicators of female students in 2016. This fact indicates that the implemented methods of distance learning in physical education did not allow to fully solve the problem of lack of motor activity of female students. The dynamics of changes in indicators of the anthropometric and functional condition of women at different stages of the research is shown in Fig. 1.



BW - body weight; ChG - chest girth; HR - heart rate at rest; SBP - systolic blood pressure; DBP – diastolic blood pressure; PP - pulse pressure; BK - vital capacity of lungs

**Figure 1.** The dynamics of changes in indicators of the anthropometric and functional condition of women at different stages of the research

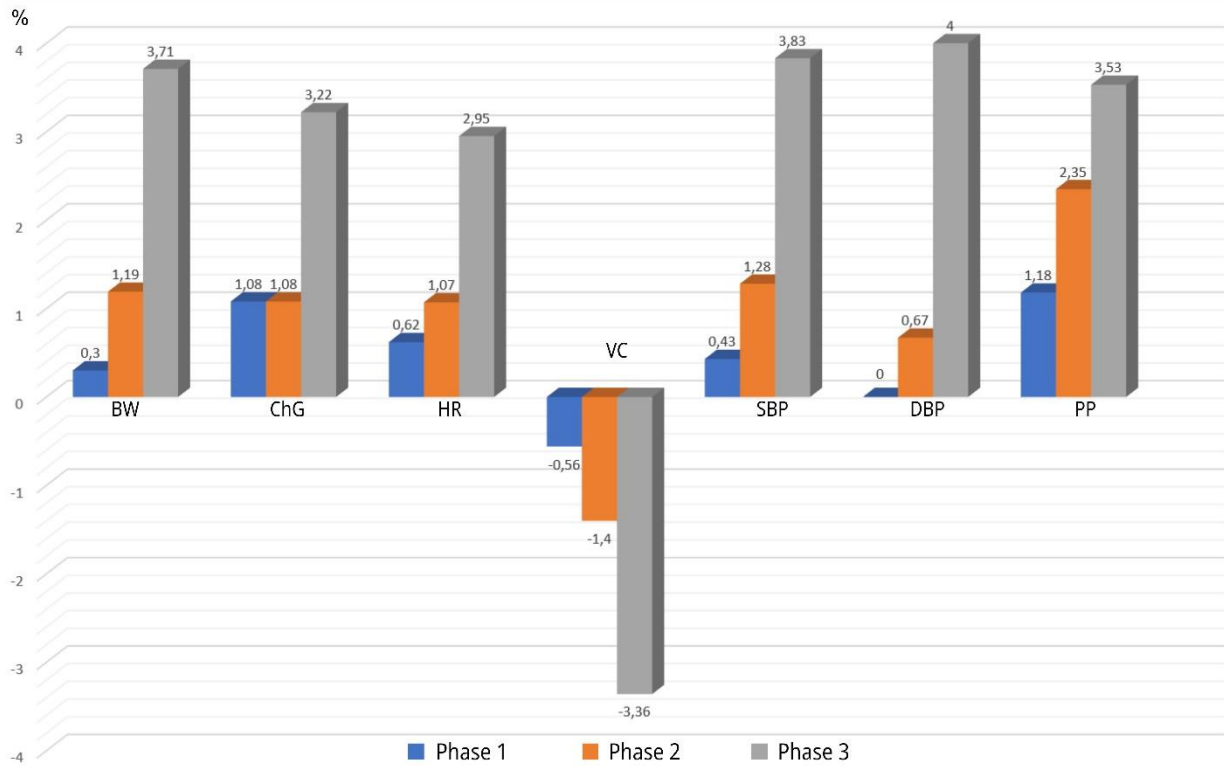
The results of the study of functional indicators of the physical condition of men showed that HR at rest has a tendency to increase, see Table 1. During the period 2016-2020, the growth of HR indicators was +1.07% ( $p>0.05$ ), and during the period of quarantine restrictions, the growth of HR was +2.95% ( $p>0.05$ ), which indicates the decrease in the level of training of young people.

The results of the study of SBP and DBP indicators of men before the introduction of the quarantine ranged within the age-specific norm of functional development. After the end of the COVID-19 quarantine, the increase of SBP +3.83% ( $p>0.05$ ) and DBP +2.67% ( $p>0.05$ ) was noted, which indicates changes in the work of the cardiovascular system of men.

The analysis of vital lung capacity (VC) indicators of men who entered the first course of study showed that the VC indicators correspond to the norms of age-related development of students, but are on its delicate border. The

comparative analysis of the average statistical indicators of VC indicates its decrease by 1.40% ( $p>0.05$ ) in 2020 and by 3.36% ( $p<0.05$ ) in 2023 compared to the indicators of men in 2016. Deterioration of indicators of the cardiovascular and respiratory system indicates the decrease in the level of functional capabilities of men, which is a consequence of leading a sedentary lifestyle during the quarantine restrictions. The dynamics of changes in indicators of anthropometric and functional condition of men at different stages of the research is shown in Fig. 2.

One of the best ways to assess the state of health of students is the analysis of morphofunctional indicators of physical development. When conducting functional testing with students, we obtained the following data: life index (LI), human energy potential index (IR), endurance index (CV), body mass index (BMI), Ruffier index (RI). The obtained data are presented in Table 2.



BW - body weight; ChG - chest girth; HR - heart rate at rest; SBP - systolic blood pressure; DBP – diastolic blood pressure; PP - pulse pressure; BK - vital capacity of lungs

**Figure 2.** The dynamics of changes in indicators of anthropometric and functional condition of men at different stages of the research

**Table 2.** Indicators of the morphofunctional state of physical health of students at different stages of the research (X± m)

Indicators	Research phases						
	At the beginning of the study	Phase 1	Phase 2	Changes	Phase 3	General changes	Changes %
<b>Group of girls (n = 697)</b>							
BMI (kg/m <sup>2</sup> )	21.21 ± 1.52	21.35 ± 1.65	21.5 ± 1.71	+0.29 ±0.19	21.82 ± 1.78	+0.62±0.26	+2.87
LI (ml/kg)	51.25±3.62	50.17±3.22	49.30±3.74	-1.95 ±0.4	47.01±3.37	-4.24 ±0.45	-8.77
IR (unit)	93.9 ± 4.31	94.37 ± 4.12	95.36 ± 4.68	+1.46±0.37	99.36 ± 3.84	+5.46±0.47	+5.81
CV (unit)	19.42 ± 1.75	19.28± 1.61	19.40± 1.53	-	19.48 ± 1.94	-	+0.31
RI (unit)	8.45 ± 1.44	8.68 ± 1.54	8.74 ± 1.62	+0.30 ±0.18	9.12 ± 1.73	0.67 ±0.29	+7.93
<b>Group of boys (n = 192)</b>							
BMI (kg/m <sup>2</sup> )	22.03 ± 1.46	21.99 ± 1.53	22.14 ± 1.68	+0.12 ±0.22	22.63 ± 1.77	+0.61±0.31	+2.72
LI (ml/kg)	53.05±3.23	52.59±3.58	51.69±3.71	-1.36 ±0.48	49.43±3.42	-3.62 ±0.19	-6.84
IR (unit)	87.54 ± 3.64	88.5 ± 3.95	89.61 ± 3.88	+2.07±0.31	93.57 ± 4.16	+6.03±0.52	+6.88
CV (unit)	17.53 ± 1.38	17.44± 1.44	17.31± 1.49	-0.22±0.11	17.43 ± 1.56	-0.1±0.18-	-0.57
RI (unit)	6.84 ± 1.72	6.91 ± 1.76	7.03 ± 1.83	+0.19 ±0.09	7.34 ± 1.92	+0.50 ±0.2	+7.31

The body mass index (BMI) is most often used to assess whether a person's body weight corresponds to his or her height. The body mass index indicator allows to determine whether a person's weight is insufficient, normal or excessive [24]. Analysis of the average statistical data of body mass index indicators shows that they are within the age-related development of girls and boys. At the same time, there is a trend towards a gradual increase in BMI. In 2023, the growth of the BMI indicator of girls of the first year of study was +2.87% ( $p < 0.05$ ) of men +2.72% ( $p < 0.05$ ) compared to the indicators of students in 2016. It should be noted that female students who were transferred to special medical groups due to their health did not participate in our research. More than half of the students of special medical groups are overweight and have a low level of physical activity [25].

The life index (LI) characterizes the efficiency of oxygen saturation of human body organs. The comparative analysis of the average statistical data of the life index of female students studied by us in the period 2016-2023 showed that its indicators corresponded to the norms of age-related development of girls and ranged from 47.01 to 51.25 ml/kg. At the same time, there is a trend towards deterioration of the LI indicator. The comparative analysis showed that this indicator was 8.77% ( $p < 0.05$ ) worse for female students in 2023 than for female students in 2016.

The comparative analysis of the average statistical data of the life index (LI) of men who entered the first course of study in the period 2016-2020 showed that its indicators corresponded to the norms of age-related development and ranged from 51.69 to 53.05 ml/kg. In 2023, the LI indicator fell below the norm of age-related development of men and amounted to 49.43 ml/kg. The comparative analysis showed that this indicator was 4.48% ( $p < 0.05$ ) worse for students in 2023 than for students in 2020 and 6.84% ( $p < 0.05$ ) worse than for students in 2016. This fact indicates the worsening of the respiratory system of women and men due to a sedentary lifestyle during the period of quarantine restrictions COVID-19.

The Robinson index (IR) is the indicator of the reserve and efficiency of the cardiovascular system. The human energy potential index (IR) is an indicator of the reserve and efficiency of the cardiovascular system. The IR indicator normally should not exceed 85 conventional units [26]. Scientists note that the lower the IR, the higher the maximum aerobic capacity and, therefore, the level of somatic health of the individual [27, 28]. The analysis of the IR indicator proves that the average statistical data of the state of the energy potential of girls are at a level lower than the determined norm and has a steady tendency for deterioration.

The analysis of IR indicators of men shows that this indicator is at a level below the average and has a persistent tendency to deteriorate. The comparative analysis showed

that for men who entered the first year of study in 2023, this indicator was worse by 4.42% ( $p < 0.05$ ) than among students in 2020 and by 6.88% ( $p < 0.05$ ) worse than among students in 2016.

An important indicator of the functional state of the cardiovascular system in a state of relative rest is the endurance index (CV). The smaller the absolute value of CV, the higher its estimate [29, 30]. Average statistical indicators of CV of women and men did not undergo reliably significant changes and ranged from 0.31 to 0.57%. This fact indicates the high adaptive capacity of the students' bodies to changes in living conditions during quarantine restrictions.

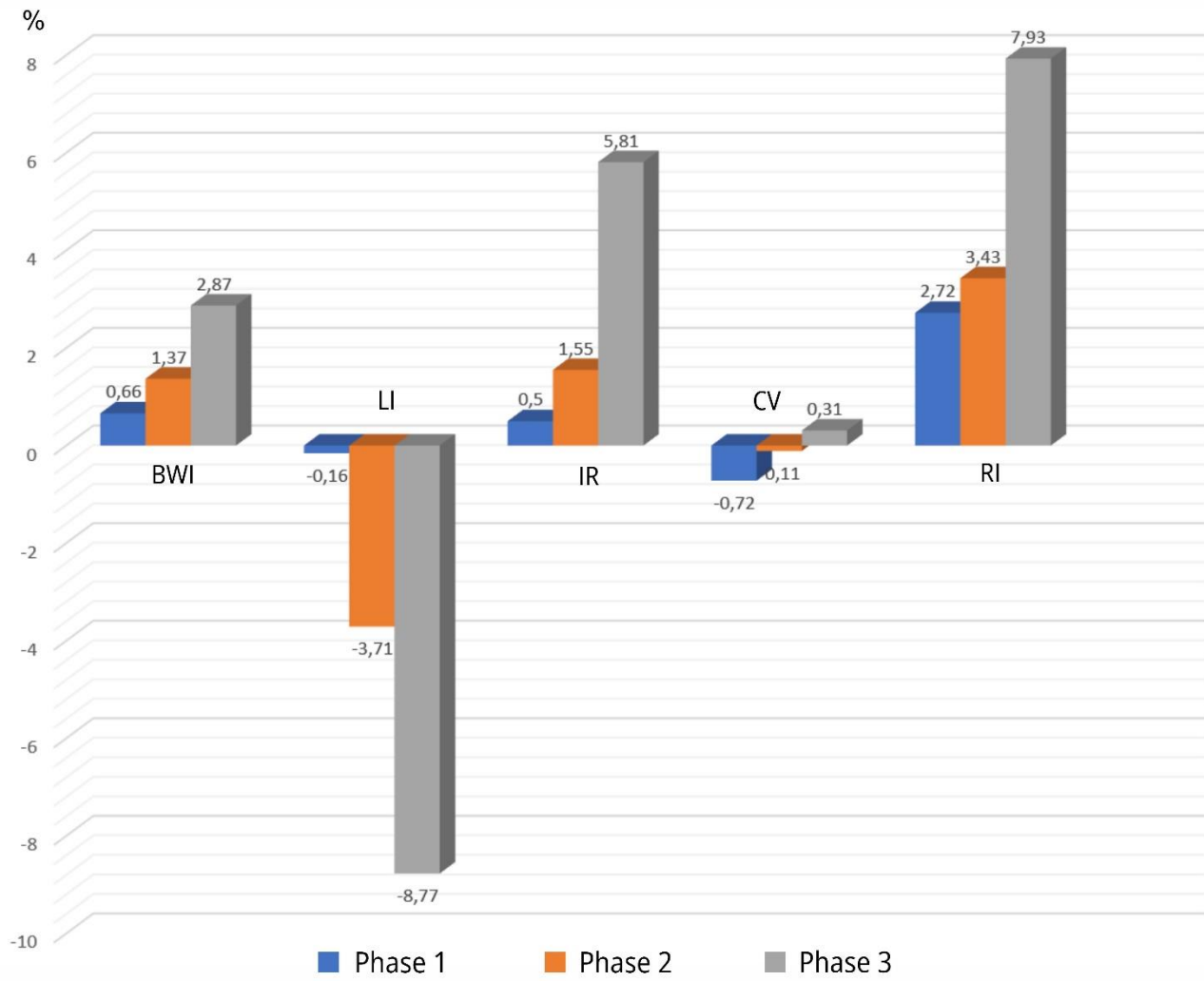
In Ukraine, since 2009, during medical examinations for the purpose of obtaining permission and dividing pupils and students into health groups for conducting physical education classes, the determination of the Ruffier index (RI) has been used. RI makes it possible to get an idea of the functional state and recovery processes of the cardiovascular system. IR results are evaluated depending on the age of the subjects. For the age category of 15 years and older, they are up to 0.5 excellent; 0.5-5 good; 5.1-10 satisfactory; 10.1-15 weak; 15.1 and more – bad.

The analysis of the average statistical data of RI showed that the indicators of the working capacity of the heart of female students during physical exertion have a tendency to deteriorate. In the period of 2016-2020 (before the beginning of quarantine restrictions), changes in the RI indicator amounted to +3.43% ( $p < 0.05$ ), and in the period of 2020-2023 (after the end of quarantine restrictions), changes in the RI indicator amounted to +4.34% ( $p < 0.05$ ). The overall changes in the IR indicator in 2023 compared to the indicators in 2016 amounted to +7.93% ( $p < 0.05$ ).

The analysis of the average statistical data of the Ruffier index (RI) showed that the performance indicators of men's hearts during physical exertion are at a satisfactory level and have a tendency to deteriorate. In the period of 2016-2020, changes in the RI indicator amounted to +2.78% ( $p < 0.05$ ), and during the period of remote physical education classes, changes in the IR indicator amounted to +4.41% ( $p < 0.05$ ). The overall changes in the RI indicator in 2023 compared to the indicators in 2016 amounted to +7.31% ( $p < 0.05$ ). This fact indicates a decrease in the level of training of the cardiovascular system and an increase in fatigue in girls and boys after physical exertion, which is a consequence of the decrease in the level of motor activity during the period of quarantine restrictions and the introduction of restrictions on the conduct of physical education classes.

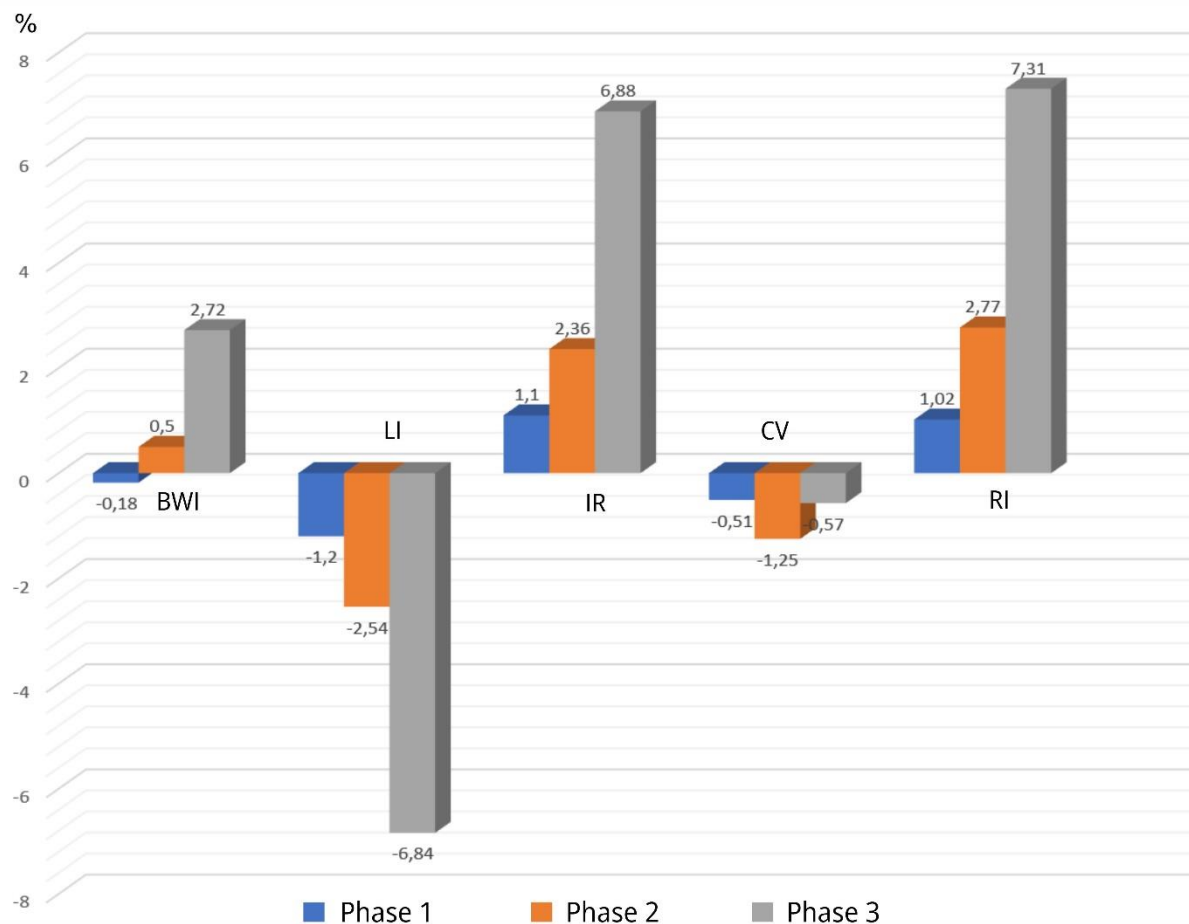
The dynamics of changes in indicators of the morphofunctional state of women at different stages of the research is shown in Fig. 3. The dynamics of changes in indicators of the morphofunctional state of men at different stages of the research is shown in Fig. 4.





BMI - body mass index; LI - life index; IR - human energy potential index; CV - endurance index; RI - Ruffier index.

**Figure 3.** The dynamics of changes in indicators of the morphofunctional state of women at different stages of the research



BMI - body mass index; LI - life index; IR - human energy potential index; CV - endurance index; RI - Ruffier index.

**Figure 4.** The dynamics of changes in indicators of the morphofunctional state of men at different stages of the research

## 4. Discussion

Preserving the health of students is one of the priorities of any educational institution. Human health is a qualitative characteristic consisting of a set of quantitative parameters: anthropometric (height, weight, chest volume, sizes of organs and tissues); physical (pulse rate, blood pressure, body temperature); biochemical (content of chemical elements in the body), functional (quality of work of human systems and organs) and others. To determine the state of human health, there is a concept of “norms”, when the parameter values fall within a certain range developed by science and practice. Deviation of the value from the given range can be a sign and evidence of deterioration of health [31]. The state of health of students depends to a large extent on the specific conditions of life, lifestyle and the organization of the educational process [11].

The initial indicators in determining the state of health of young people are the analysis of anthropometric indicators [16, 32]. Anthropometric measurements make it possible to characterize deviations in physical development, establish body proportions, determine the percentage of fat and find

out a number of other important indicators for human health. Anthropometric studies of the component body composition of young people aged 17-19 years showed that modern students have a worsening body mass index due to the increase in fat and a decrease in the muscle component of the body [33].

Assessing person's health level based only on anthropometric indicators does not give a complete picture of its condition. More informative are the functional indicators of the work of human systems and organs, which allow to assess the level of adaptation of the organism to the environment, physical load and analyze the recovery processes after loads [17, 34]. Conducting physical education classes is impossible without taking into account the individual characteristics of the students' bodies obtained with the help of medical and biological research methods [7, 21]. The basis of physical education classes is exercises aimed at increasing the functional capabilities of the body, strengthening health and increasing the level of physical fitness of students [2, 8, 9, 28]. Some researchers propose the methodology for developing physical education programs aimed at improving the functional

capabilities of students bodies based on establishing their somatotype. This will allow the selection of physical exercises and types of motor activity that most optimally correspond to the individual capabilities of the students. The use of this method in health physical culture is a reserve for increasing the effectiveness of physical education classes [23, 35]. Most often, scientists express the opinion that the state of health and the development of functional systems of the body primarily depends on the conscious and purposeful physical activity of students [6, 13, 14, 16].

The COVID-19 pandemic and the announced quarantine have made adjustments to the education system and determined the need to form new views on the organization of the system for preserving the health of students and developing their physical activity. As noted by Crisol Moya and Caurcel Cara [20], new educational strategies and technologies based on the creation of innovative learning have led to the emergence of a methodology based on the active participation of students in their learning. Modern pedagogical technologies of physical education are based on the joint activity of the teacher and the student in the projecting, organization and implementation of the student's individual mode of motor activity [37-39].

The use of modern information and communication technologies contributes to the formation of a stable interest and positive emotional attitude of students to physical exercises, health activities and physical self-improvement. In order to form a motivational and valuable attitude towards the development of motor activity, it is necessary to teach young people to analyze their own sports achievements, to search for ways of personal physical development, and to develop the ability to organize their own leisure time without harming health [40, 41].

Physical activity is one of the key aspects of maintaining the health of young people. Low level of physical activity and a predominantly sedentary lifestyle are the main factors affecting the health of students [36]. The results of our research confirm the data [13, 17, 36], about the negative tendency of students to lead a sedentary lifestyle, about the significant advantage of a sedentary level of physical activity, especially during the period of quarantine restrictions [2, 6, 11]. The research we conducted allowed us to establish new data of indicators of the anthropometric, functional and morphofunctional states of health of students after two years of restrictions on conducting physical education classes due to the spread of the COVID-19 pandemic.

## 5. Conclusions

The problem of preserving the health of young people has acquired the status of a priority direction in the last decade. Solving this problem during studies in institutions of higher education involves the implementation of a number of directions, namely: improvement of the system

of control and monitoring of students' health; promotion and stimulation of a healthy lifestyle and valeological education; introduction of innovative forms of physical education. The most effective means of improving students' health indicators is systematic exercise and various types of motor activity.

The general trends of the decrease in the level of physical activity and the state of health of students were aggravated by the introduction of quarantine restrictions caused by the COVID-19 pandemic. Girls showed the biggest changes in: increase in body weight (BW) +4.09% ( $p<0.05$ ); increase in chest girth (ChG) +5.2% ( $p<0.05$ ); decreased vital capacity of the lungs (VC) - 4.51% ( $p<0.05$ ); deterioration of the life index (LI) -8.77% ( $p<0.05$ ); deterioration of the index of the reserve and the efficiency of the cardiovascular system (IR) +5.81% ( $p<0.05$ ); increase in the rate of recovery of the cardiovascular system after physical exertion (RI) +7.93% ( $p<0.05$ ). Men showed similar trends of changes in indicators of the state of physical health. They were: increase in body weight (BW) +3.71% ( $p<0.05$ ); increase in chest girth (ChG) +3.22% ( $p<0.05$ ); decreased vital capacity of the lungs (VC) - 3.36% ( $p<0.05$ ); deterioration of the life index (LI) -6.84% ( $p<0.05$ ); deterioration of the index of the reserve and the efficiency of the cardiovascular system (IR) +6.88% ( $p<0.05$ ); increase in the rate of recovery of the cardiovascular system after physical exertion (RI) +7.31% ( $p<0.05$ ).

The comprehensive comparative analysis of the average statistical indicators of the state of health of young people in the period 2016-2023 showed anthropometric, functional and morphofunctional changes in the state of health of students, which indicate the appearance of excess weight, the deterioration of indicators of the work of the cardiovascular and respiratory systems, and as a result – decrease in the energetic potential of working capacity of girls and boys. During the period of quarantine restrictions, the negative processes of deterioration in student health indicators accelerated twofold.

The way out of the negative situation can be the increase of the motivation of young people to engage in sports independently. Modern information and communication technologies provide teachers with ample opportunities to stimulate students to engage in various traditional and special types of motor activity. The basis of this approach is the individual motivational and value attitude of students towards their own physical development. The task of the teacher is to provide students with theoretical, methodological and advisory assistance in conducting independent classes on the chosen type of motor activity.

## Conflicts of Interest

There is no conflict of interest between the authors.

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