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CHANGES IN THE PHYSICAL FORM OF STUDENTS DURING THE COVID-19 PANDEMIC

Abstract. This research aim is to study the changes of young people's physical fitness during the first year of quarantine restrictions driven by the pandemic situation.

The main challenge of the research proved to be data gathering from multiple sources, its grouping and stratification and also ensuring that the selected subset is robust. Data stratification included various parameters such as age, gender and physical fitness of students. Possible distortion of the results due to non-compliance to gender conformity has been considered in particular and evaluated. Close analysis of gender specifics in the data and its correction using random numbers generator allowed to avoid inconsistencies. Statistical significance of subset's parameters changes was controlled by calculations of confidence intervals.

Statistical analysis of students' physical fitness evaluation in 2019 fall semester and 2020 fall semester has been carried out.

The calculations included average values of testing results, standard deviation of the results (σ_i), mean values ($\sigma_{\bar{x}}$), confidence interval for average values and 50% percentile. Overall for university average values of students' physical fitness score have dropped from 13.4 to 12.7 within the considered year (maximum score was 20 points). 50% percentile also has dropped from 14 to 13.

Indicators of the 2019 and 2020-year sets differ with statistical validity of not less than 95%.

Results of the research have shown a relatively small decrease in students physical fitness due to the changes of lifestyle and ways of education organization during COVID-19 pandemic. The average change is evaluated to 5%. In 1 to 5 score range we are talking about a decrease from 3+ to 3. Nevertheless this small drop has been observed throughout all stratas: male, female, and any other values of the rest of parameters. This allows to draw the conclusion about the existence of general negative trend.

Keywords: COVID-19, quarantine, lockdown, physical fitness.

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ЗМІНА ФІЗИЧНОЇ ФОРМИ СТУДЕНТІВ ПІД ЧАС ПАНДЕМІЇ COVID-19

Анотація. Метою цього дослідження є вивчення змін фізичної підготовленості молодих людей протягом першого року карантину, викликаних ситуацією з пандемією.

Основною проблемою дослідження виявився збір даних з кількох джерел, їх групування та стратифікація, а також забезпечення надійності обраної підмножини. Стратифікація даних включала різні параметри, такі як вік, стать та фізична підготовленість студентів. Зокрема, було розглянуто та оцінено можливе спотворення результатів через недотримання гендерної відповідності. Ретельний аналіз гендерної специфіки даних та її корекція за допомогою генератора випадкових чисел дозволили уникнути невідповідностей. Статистична значущість змін параметрів підмножини контролювалася розрахунками довірчих інтервалів.

Проведено статистичний аналіз оцінки фізичної підготовленості студентів в осінньому семестрі 2019 року та осінньому семестрі 2020 року. Розрахунки включали середні значення результатів тестування, стандартне

відхилення результатів ( ), середні значення ( ), довірчий інтервал для середніх значень та 50% процентиль.

Загалом по університету середні значення балів фізичної підготовленості студентів протягом розглянутого року знизилися з 13,4 до 12,7 (максимальний бал – 20 балів). 50% процентиль також знизився з 14 до 13.

Показники наборів 2019 і 2020 років відрізняються статистичною достовірністю не менше ніж на 95%.

Результати дослідження показали відносно невелике зниження фізичної підготовленості студентів через зміни способу життя та способів організації навчання під час пандемії COVID-19. Середня зміна оцінюється в 5%. У діапазоні від 1 до 5 ми говоримо про зниження від 3+ до 3. Проте це невелике падіння спостерігалося у всіх стратах: чоловічому, жіночому та будь-яких інших значеннях решти параметрів. Це дозволяє зробити висновок про наявність загальної негативної тенденції.

Ключові слова: COVID-19, карантин, локдаун, фізична підготовка.

Introduction. Possible impact of COVID-19 pandemic restrictions and quarantines on people's health and physical fitness has been raising a wider interest in such fields as medicine, biology, physical well-being [1,2].

Aim of this research is to investigate the impact of the first COVID-19 pandemic restrictions on the physical fitness of the students of Kharkiv National University of Radio Electronics (KNURE) studying their fitness condition evaluation before the pandemic and after the first year of quarantine restrictions. As KNURE is not a specialised institution (as would be for example military or sports ones) the results of the research can be generally extended to other students in Ukraine and other countries close to us.

We all lived through a difficult year of quarantine restrictions:

- gyms and sports sections were closed;
- students studied remotely (practically never left home);
- the motoric activity of people has generally reduced;
- social interaction was limited;
- illnesses of the close ones and grievous newsfeeds had a negative impact to people’s mental condition.

While before the pandemic, students were able to and even obliged to exercise and undertake physical education under the guidance of experienced teachers and coaches at least 4 hours a week, did they have means and the desire to perceive it on their own during the quarantine? Has the physical fitness of young people changed during the year of the pandemic and at which scale?

The imposed restrictions listed above suggest a likely deterioration in physical fitness condition. On the other hand, the pandemic has created a number of ‘positive’ factors:

- extra free time that used to be spent commuting to university/work;

- there was an opportunity to improve nutrition (home cooking);
- students from other cities stayed at home in more comfortable, familiar and often more environmentally friendly conditions;
- time freed from social activities could be spent on self-education, self-organization and self-improvement, including sports.

The main task is to find out whether people's physical fitness changed during the pandemic year, and which factors (negative or positive) were more influential. This question is lacking a ‘digitized’ answer. There are no quantitative estimates that can be compared. It is due to several reasons:

1) not enough time has passed since the pandemic began to see a clear change and trend;

2) as this ‘experiment’ was not planned, there was no structure set to collected data or standardized test exercises;

3) during the quarantine the education and assessment process has been dominantly remote which is different from the historically formed practices;

4) conducting a remote assessment of a person's physical fitness is not a straightforward task in general.

Materials and methods

Statistical observations

Initial data for this research includes the results of test assessment of student's physical fitness in the 2019 fall semester and the 2020 fall semester. From one hand each student has a score (grade) in the semester results, on the other hand – each single score is a complex evaluation which includes classes attendance as well as both practical and theoretical tests results. It is not possible to separate out only physical fitness condition evaluation from the general score.

The data for physical fitness evaluation has been obtained from the protocols of the sport sections in 2019 and from the information on the remote education website in 2020. The details of those will be given later in the paper.

For different reasons the volume of reliable input information has proven to be rather limited. It has lead to a necessity to form statistical samples and run statistical analysis. Statistical data had to be specially formed using aggregation and generalisation methods.

Statistical data in our case is a set of objects (students of KNURE) and attributes (parameters) that characterise them. On the basis of the prior knowledge and analogous research it is possible to define the next main parameters for input data stratification:

- gender parameters,
- age parameters,
- students physical fitness;
- faculties (specialties) of education.

Gender parameters were investigated (shown below) and defined as essential ones. They were used for random samples formations.

Age parameters were also taken into account in the samples formation. On the one hand, all students roughly belong to the same age group (18-24 years old). On the other hand, each year the set of students is renewed by a fifth: last-year students leave the university and the first-year students are replenished by school graduates – both of those sets were not taken into consideration. In addition, the set of master degree students was excluded from the analysis as well. The reason for the latter is that the master's program at KNURE includes not only its own graduates from the bachelor program but also those of other universities. In most cases, it was impossible to trace their physical condition assessment through-over both 2019 and 2020 fall semesters. Therefore, the 2019 and 2020 sample sets for the research were formed of 2nd, 3rd, and 4th year students.

The physical fitness characteristics of the students were considered in the sample design as follows. At KNURE, special groups are formed for students with illnesses or special developmental characteristics in physical education classes, which are engaged in separate physical programs. These groups are called special medical groups. Students from these groups were also excluded from consideration during the research. As well as students who happen to be members of national teams for all sports. Such students study and exercise according to individual plans, they would had been involved in sports since a young age, and have a distinct advantage over others in terms of physical fitness.

Students partition by a department is a natural element of the educational process in any university. This partition often simplifies the formation of initial data for analysis and is a natural stratification of the data. The criteria for dividing students into faculties, of course, have nothing to do with their physical abilities. However, when examining these groups of data (by faculty and by study group), some patterns emerged. For example, there were groups of data for which the standard deviation (σ_i) was practically zero. There were also groups for which the second quartile ($Q2$ or 50% percentile) was almost the same as the upper limit of the data range. The reasons for these results were not investigated, they were simply excluded from consideration as gross errors.

Using stratification, generalization and aggregation methods (to be shown later in the paper) made it possible to assess the correlation and interrelations between groups of data, and also to investigate the totality of data by means of its systematization and subdivision into qualitatively homogeneous groups and to calculate the appropriate generalized statistical indicators [3].

Description of tests and data sources

Objectively, the types of final tests in the 2019 and 2020 fall semesters differed. The forms and ways in which this data was stored differed as well (the source documents that were used to generate statistical samples).

Before the quarantine (including the 2019 fall semester) in KNURE and in other higher education institutions of Ukraine the assessment of the physical state of students was carried out with the help of ‘Tests and standards for the quarterly

assessment of physical preparedness of the population of Ukraine' (Order of the Ministry of Youth and Sports of Ukraine № 4665 of 15.12.2016) [4].

For higher education students' types of tests and assessment scale of physical preparedness are given in Table 1.

Table 1.

Tests and standards for the assessment of physical fitness of students in 2019 fall semeter

Types of tests	Gender	Normativity, scores			
		5	4	3	2
Steady running 3000 m, (min)	M	13,0	13,3	14,2	15,3
2000 m, (min)	F	10,3	11,15	11,5	12,3
Pull-ups on the bar (number of times), or long jump from a place, (cm)	M	14 260	12 240	11 235	10 205
Push-ups in the supine position (number of times) or long jump from a place, (cm)	F	25 210	21 200	18 185	15 165
100 meters sprint running, (sec)	M	13,2	14,0	14,3	15,0
	F	14,8	15,5	16,3	17,0
Shuttle runing 4 x 9 м, (sec)	M	9,0	9,6	10,0	10,4
	F	10,4	10,8	11,3	11,6
Torso tilt forward from sitting position, (cm)	M	13	11	9	6
	F	20	18	16	9

These tests are traditional standard exercises. A description of them can be found in the [5,6].

Students took these tests in the 2019 fall semester at the stadium or in the gym. The results were scored and recorded by teacher/instructors.

In 2020 fall semester, all classes at the university were administered remotely. This included physical education classes. On a special website, students were able to attend theory classes online, consult with instructors, take and discuss theory assignments, and participate in tests of their physical fitness evaluation. Students recorded video files of their performance on the given tests. The files were uploaded to the specified remote learning website, and the instructor evaluated the quality of the tests performed and scored them. Publicity of materials allowed to reduce to zero errors of identification of the test participant and evaluation of results. But, unfortunately, it is not possible to perform all the exercises suggested in Table 1 at home in front of a video camera.

Tables 2 and 3 show the test types and grading scale for the fall 2020 semester of remote learning.

Table 2.

Control tests of the 7th week of study

Types of tests	Gender	Normativity, scores			
		5	4	3	2
Torso tilt forward from sitting position, (cm)	M	19	16	13	10
	F	20	17	14	10
Raising the torso to a sitting position in 30 sec (number of times)	M	27	24	21	19
	F	24	21	19	16

Table 3.

Control tests of the 8th week of study

Types of tests	Gender	Normativity, scores			
		5	4	3	2
Push-ups in the supine position(number of times)	M	52	44	38	32
	F	24	19	16	12
Jumping rope in 60 seconds (number of times)	M	110	90	80	70
	F	95	85	75	65

In the title of the tables, there are the tests types indicators: ‘7th Week of Study’ and ‘8th Week of Study’. These names are conditional. They are presented on the site of KNURE remote learning as following [7].

Tests №1 of week 7 are flexibility tests.

Tests №2 of week 7 and Tests №1 of Week 8 are strength tests.

Tests № 2 of week 8 are speed and endurance tests.

Specifics of the 2020 test lie in the fact that the resulting grades sheets contain the aggregated scores for the 7th and 8th weeks tests combination having a maximum score of 10. It is not possible to separate these scores for individual tests.

Also the 2020 tests (Tables 2 and 3) are not exactly identical to the 2019 tests (Table 1). The 2019 the long jump from a place was also assessed in KNURE. However, collectively, they reflect the same physical abilities of an individual.

For comparative analysis, the 2020 results for all tests from Tables 2 and 3 and the 2019 results for the following tests were used (see Table 1):

- pull-ups on the crossbar or flexion and extension of the arms in the prone position,

- pushing the trunk forward from a sitting position,

- shuttle run,
- long jump from a place.

Description of the initial data for the analysis

Classes in physical education in KNURE are conducted by sports sections. In 2019 the tests were conducted by the heads and coaches of the sections. Test results were recorded in the protocols with the designation of types of tests and results: actual (measured in physical units) and in score points according to Table 1. Each student's records included last name, gender, name (number) of the study group, faculty. In addition, the sum of score points for all types of tests was calculated.

The sum of score points in the grade report form is a combined assessment of the tests passed, class attendance and results of theoretical work. Separating these components in the grade report form is not possible. Therefore, it is not possible to use a grade report form for the purposes of the research.

For the statistical analysis we used the data from the protocols. This is an official document, signed by the teacher or/and section coach.

Table 4 shows the names of sections and the number of students (test participants) whose tests results in 2019 were available for the research.

Table 4.

Number of sports section protocols and students which undertook the testing in 2019 fall semester

№	Name of Section	Number of protocols	Number of students
1	Badminton	5	140
2	Basketball	5	132
3	Volleyball	8	224
4	Track and field athletics	4	112
5	Ping-pong	9	252
6	Tennis	1	25
7	Aerobics	4	98
8	Mini soccer	3	75
9	Boxing, wrestling	2	53

A total of 1,103 students and 4,412 test scores were included in the raw input data.

The formation of the sample was a purely technical issue. It was necessary to digitize the data and stratify it by specified gender traits and faculties. The protocols did not include students of special medical groups and professional sports team members. Ensuring correct gender representation will be described below.

The research was conducted in all the faculties of KNURE, namely:

- CS - Faculty of Computer Science,
- CEM - Faculty of Computer Engineering and Management,
- ACT - Faculty of Automation and Computer Technologies,
- ITM - Faculty of Information and Analytical Technologies and Management,
- IC - Faculty of Information and Communications,

- ELBE - Faculty of Electronic and Biomedical Engineering,
- IRTIP - Faculty of Information Radio Technology and Technical Information Protection.

Further in the paper only abbreviations of faculty names will be used.

The results of the 2020 tests are presented on the KNURE remote learning website in web page format. Data is presented separately for each department and each study group. The data did not include students of special medical groups and sports team members. First- and last-year students were also excluded from consideration. Groups which didn't have sufficient number of results were also excluded. Less than 10% of all possible. The sample sizes of the 2020 results can be seen in Table 5.

Table 5.

Sample sizes of the 2020 fall semester tests results

1	2	3	4	5	6
CS	85	65 (76%)	1700	482 (28%)	671
CEM	43	21 (49%)	860	165 (19%)	225
ACT	39	5 (13)	780	23 (3%)	33
ITM	19	13 (68%)	380	85 (12%)	117
IC	38	12 (32%)	760	68 (9%)	105
ELBE	25	6 (24%)	500	18 (4%)	30
IRTIP	42	12 (28%)	840	43 (5%)	78
Total	291	69 (24%)	5820	884 (15%)	1259

The columns in the table are labeled as follows:

1 - faculty,

2 - total number of study groups in the faculties,

3 - number of study groups the students of which were included in the statistical sample (in parentheses - the share of these groups in %),

4 - total number of students in the faculties (results are rounded),

5 - number of students whose tests results were included in the sample (in parentheses - the share of these students in the total number in %),

6 - number of tests results.

Thus, the formation of the sample based on age, physical fitness characteristics, and faculty affiliation determined its volume. 2020 statistical sample included 884 students (15% of the total) from 69 study groups (24% of the total) and 1,259 tests results.

The 2019 sample size exceeds the 2020 sample by all measures.

Gender parameter

A possible influence of participants' gender traits on the results of the study was determined as following:

1) physical abilities of male and female students were compared in order to determine the need to observe gender parameters in the sample,

2) the proportion of females in the formed samples was determined, this proportion was compared to the real representation of female students in groups (the gender proportions of the sample and the general set were compared).

Analysis was conducted for all faculties for 2019 and 2020, for individual tests and for the general set.

In all cases, female's physical condition scores were higher than men's. Image 1 shows an example for the 2020 sample CS faculty.

In the vast majority of cases, female students' physical fitness scores were higher than those of male students. Image 1 shows an example for the 2020 fall semester sample of CS faculty on the flexibility, strength, speed, and endurance tests.

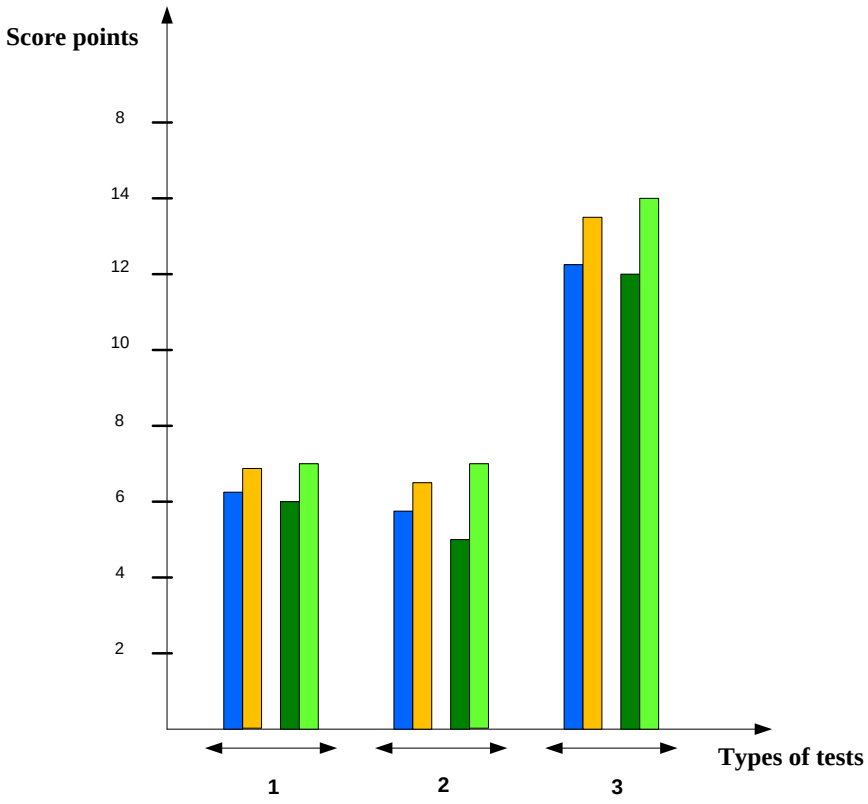

Image 1. *Estimates of male and female students' physical fitness.*

- Average value of physical fitness assessment in score points,
- male students
- female students

- 50% percentile
- male students
- female students

1 - total of 2 flexibility and strength tests (Table 2), maximum score is 10 points,

2 - total of 2 strength, speed and endurance tests (Table 3), maximum score is 10 points,

3 - total of 4 tests on flexibility, strength, speed and endurance (table 2,3), maximum score is 20 points.

Calculations were made using Statgraphics computer software. The results were obtained for 4 types of tests of 7 faculties separately for male and female students. The number of participants included 884 students.

The quality of statistical estimates was controlled by calculating 95% confidence intervals. In 35 of the 42 results, the confidence intervals of the statistical estimates for males and females did not overlap. This confirms the significance of the statistical estimates shown in Image 1.

The obtained results about the difference in the level of physical training between male and female students require careful consideration of the gender matching when forming the statistical sample.

Image 2 shows the relative number of female students in the faculties of KNURE (according to the students' records) and their relative number in the experimental sample (by faculty), which was formed only by the age and physical fitness characteristics of students. This does not take into account the gender parameter of the test participants.

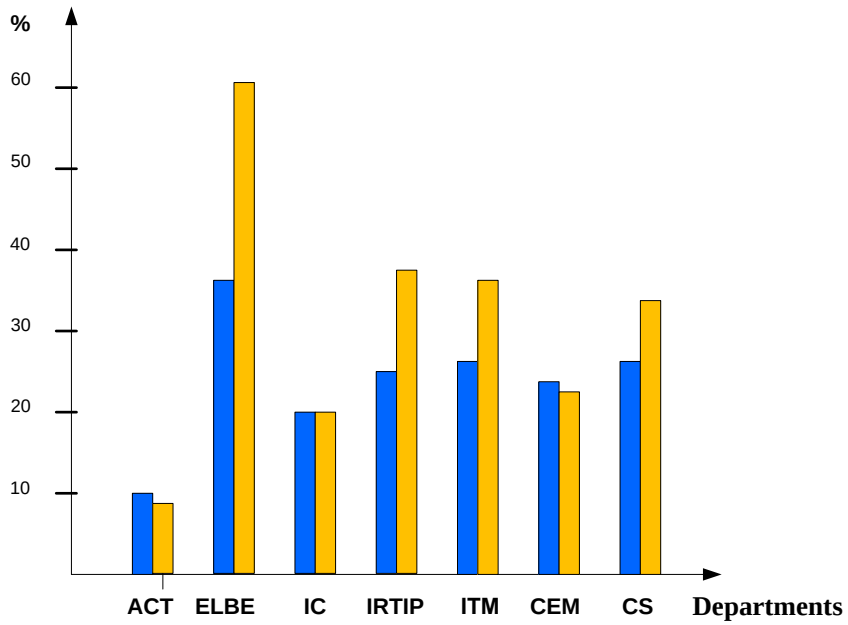

Image 2. *Relative representation of female students in official students records and in actual tests scores*

- representation of female students on student lists
- representation of female students in tests scores

Analysis of the results shown in Images 1 and 2 shows that forming a statistical sample without taking into account the gender parameter of tests participants would lead to an overestimated result: relatively bigger number of female students participated in the testing and on average they had better tests results.

Therefore, the resulting sample (which does take into account gender parameter) was formed from the initial sample (taking into account age and physical fitness characteristics parameters) by excluding 'superfluous' participants (both male and female). The randomness of the participants who were excluded was ensured by the use of a random number generator. The random number was the ordinal number of male or female students in the lists of faculty students. This procedure was performed for the 2019 and 2020 samples. This procedure caused slight reduction of the sample sizes, but allowed to maintain the correct ratio of male to female students in the statistical samples while generally ensuring the robustness of the tests scores.

Results

Image 3 shows the results of the statistical characteristics calculation of KNURE students physical fitness assessments in 2019 and 2020. The results are presented for 5 faculties and the total for the university. In all cases, the sample size exceeded 10% of the total number of students in departments and in the university as well. Two faculties were excluded from the final results. The reasons for this was the very small size of the samples (gender equilibrium result) and also the very small standard deviation of the 2020 sample. The large number of repeated online tests results was classified by the authors of the study as a gross error.

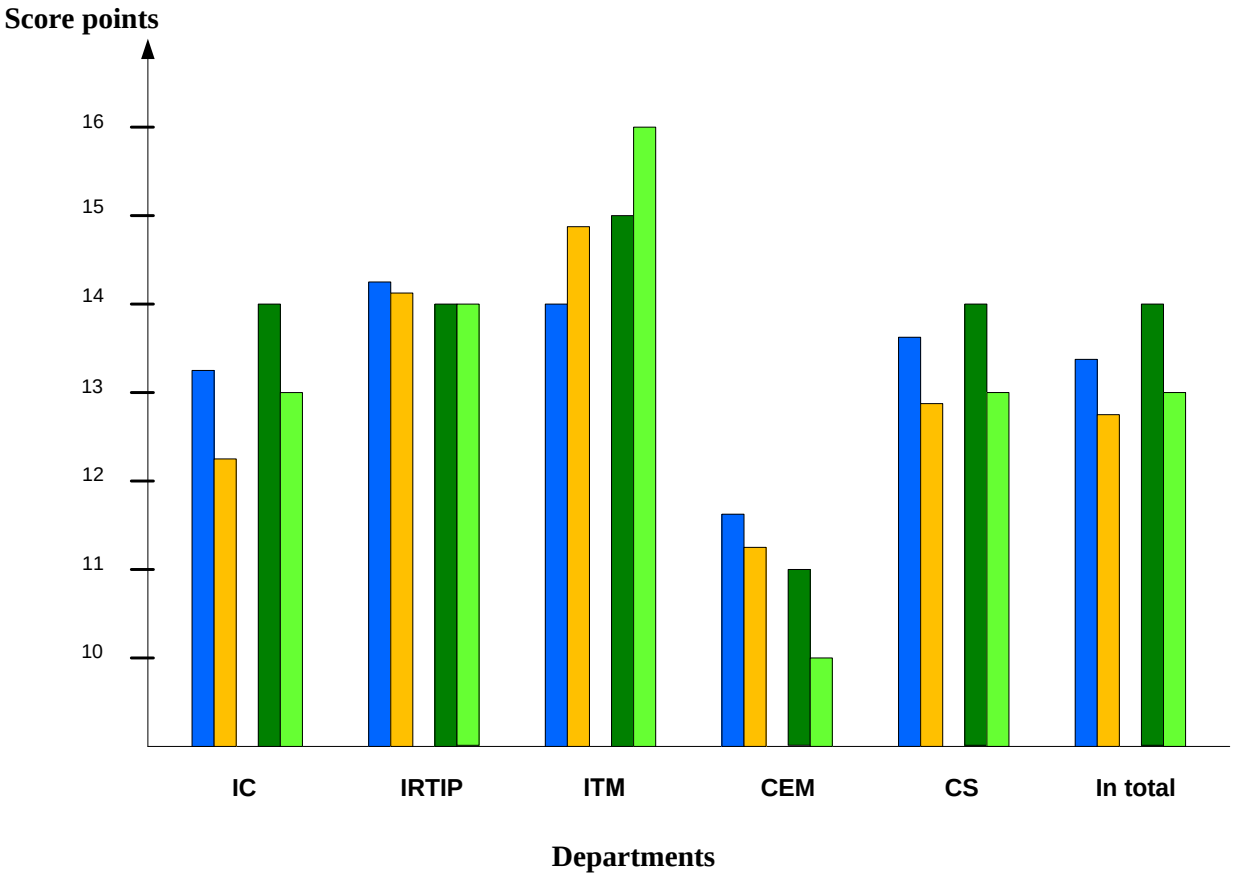

Image 3. *Comparison of students' physical fitness condition in 2019 and 2020 fall semesters*

- Average physical fitness score,
- 2019
- 2020
- 50% percentile
- 2019
- 2020

Statistical characteristics were calculated using the Statgraphics computer software [8]. The total sample size for the university was 984 students for 2019 fall semester and 759 students for 2020 fall semester.

The scores by which examiners rate students are generally measured on an ordinal scale. Their probabilities are most often distributed according to a hypergeometric law. Therefore, both sample averages and the 50% percentile were chosen for the analysis.

Standard deviations of tests (σ_i), and mean values ($\sigma_{\bar{x}}$) were calculated. Confidence intervals for $\sigma_{\bar{x}}$ values of 2019 and 2020 assessments did not overlap for

small samples (IC, IRTIP, ITM and CEM faculties) at the confidence probability $P_\partial = 0,9$. For large samples (CS faculty and the university as a whole) there was no overlap of the confidence intervals at $P_\partial = 0,95$.

Discussion

For 4 of the 5 represented faculties (IC, IRTIP, CS and CEM faculties) the evaluations of the physical fitness of the students declined. The average values and 50% percentiles decreased. Only for one faculty the grades improved.

For the university in total, students' average physical fitness scores worsened during the pandemic year. Results are given as the sum of the four tests. The maximum score value is 20 points. The minimum value is 0 points. The average for 2019 fall semester was 13.4 points; 2020 fall semester result was 12.7 points. Confidence interval estimates suggest that this change is statistically significant. The 50% percentile also decreased: from 14 to 13 points.

Unfortunately, there was no way to prepare for either a pandemic or an experiment to assess changes in the physical fitness of students. Therefore, the main effort of the study came from forming homogeneous samples. In the future planning of the research it will be easier to form larger homogeneous samples and get more accurate results.

Conclusions

The deterioration of physical fitness of people during the year of the pandemic, remote learning or work, restrictions on visits to gyms, sports clubs and playgrounds, is the expected result. The question is, how irreversible is this process? How quickly will the situation recover?

The results of the studies show that deterioration in grades is not big. In percentage terms, it's a 5% decrease. Or on a scale of 5, it is a drop from 3+ to 3. You might not even notice it. However, this (not large) deterioration was observed in all **strata**: male, female, different specialties, and so on. This suggests a trend.

Another conclusion is that the best part of the Ukrainian population (male and female students in the prime of life) has a physical fitness condition classified as not excellent, not good, but at best satisfactory.

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