

# Post-COVID-19 Pandemic Effect on University Students Fitness Level

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**Abstract:** *Background and Study Purpose:* Through the present paper, we aimed to determine to what extent physical capacity was affected by the restrictions during the pandemic. This confirmatory study hypothesizes that university students' fitness level and effort capacity decreased after the pandemic compared to the results obtained before sanitary restrictions.

*Material and Methods.* Two groups of 25 female university students in the age range between 19 and 21 years, passed six physical tests before pandemic restrictions and after the end of social confinement. The applied physical tests targeted the strength, power, flexibility, coordination, and cardio-respiratory fitness level.

*Results.* All test results, except one, demonstrate a statistically significant difference, confirming the hypothesis that the two samples differ in effort capacity and fitness abilities. By calculating the *t*-test and Cohen *d* effect size, the standardized mean difference of the pandemic effect demonstrates how substantially different are the two samples.

*Conclusions.* Data confirms the research hypothesis: physical abilities decrease was between 10 and 28 percent with the most worrying level being recorded at flexibility and abdominal strength tests. The comparison of standardized fitness test results in two successive samples of students can contribute to a better understanding of the long-term impact of the pandemic breakdown on their fitness level. A diminished physical potential of the future educated workforce would have lasting effects on their physical and mental health and consequently higher healthcare expenditure and lower productivity. Remedial measures are needed to reverse the physical potential decrease of young adults after the sanitary crisis.

**Keywords:** *physical abilities; effort capacity, fitness tests, pandemic effects.*

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## Introduction

The COVID-19 pandemic has affected people's daily lives, slowed the economy and disrupted travel and social activities. Sports competitions, leisure team physical activities, and formal physical education are among these affected social activities. Largest-scale tournaments and competitions have been postponed or cancelled, while fitness clubs, swimming pools, gyms, and playgrounds were closed to public use (Haleem et al., 2020). The postponement of the Olympic Games for a year was an extraordinary decision; the Games were previously only cancelled because of world wars. Besides, the absence of spectators amplified the disruption of the sportive performance. Hence, the priority was the athletes' and spectators' safeguards (Hoang et al., 2020), and consequently, a small audience was considered the most appropriate decision.

The premises of the present study are the low interest in youth in independent physical and recreational activities during the lockdown as it results in studies undertaken by international organisations (OECD, 2023) and researchers (Vrbik et al., 2021). In the age group of 15 to 24-year-olds, only 58% of European women participate at least weekly in sport or exercise, compared to 73% of men (Eurobarometer, 2022).

Notable is the fact that the interest in physical exercise diminishes with age. A large survey, including 14 countries reported that 42% from adults reported a decreased of moderate to vigorous physical activity during COVID-19 restrictions (Wilke et al., 2021). Even before the pandemic breakdown, university students tended to reduce the time and energy allocated to physical activity, as another comprehensive study shows, concluding that the prevalence of physical inactivity among university students in 23 countries was 41% (Pengpid et al., 2015). This tendency became even more pronounced during the pandemic, especially among female students. Ferrara et al. (2022) found that just 39,2% of female university students practice physical activities once or twice a week.

The COVID-19 pandemic and its effect on significant changes in the learning environment for university students was and still is a vast subject for researchers. There is a large amount of research on sanitary restrictions' effects on physical education in universities. The main interest was directed at mental health (Xiang et al., 2020; Arora & Grey, 2020), weight gain (Pop & Ciomag, 2021), behaviours (Bielec & Omelan, 2022; Al-Haifi et al., 2023), and students' attitudes towards physical activity based mainly on self-reported data, which is susceptible to cognitive bias (López-Valenciano et al., 2021).

Research based on fitness test (Mozolev et al., 2021) begins to appear once university courses and life, in general, have returned to normal. However, research focusing on standardised fitness testing in young adult samples is rarer due to insufficient data. The present research is addressing this nish in literature, being one of the few empirical studies and the first at national level based on direct measurements in physical tests.

Through the present paper, we aimed to confirm our observations in the pedagogical process and to determine to what extent physical capacity was affected by the restrictions during the pandemic. This confirmatory study hypothesizes that university students' fitness level and effort capacity decreased amid pandemic compared to the results obtained before sanitary restrictions.

## Material and methods

*Participants.* Fifty female students at Bucharest University of Economic Studies, in the Economy and Marketing faculties, part of two groups of 25 each, passed six physical tests. The inclusion criteria were to be healthy and actively participate in physical education lessons from the university curriculum. All students were in their first year of university, in the age range between 19 and 21 years. The participants were informed about the protocol of the study. All participants gave their informed consent.

### *Research design.*

Two equal groups of female students were assessed in different physical abilities. The first sample was tested in February 2020, within regular physical education lessons in face-to-face mode. This group provided a baseline for comparing the findings with the second sample, which passed the same tests in April 2022 after almost two years of remote learning and two months after returning to traditional classes.

The applied physical tests targeted the strength (sit ups and squads in 30s), power (standing long jump), flexibility (sit and reach), coordination (Matorin test), and cardio-respiratory fitness level (Ruffier test).

Standing long jump tests the explosive leg power. The contributions of muscle in the propulsive phase of this jump are estimated to be 45.9% the hip, 3.9% knee, and 50.2% ankle muscle (Xia et al., 2021). The best of two attempts was measured.

The sit and reach test for flexibility has been assessed with ratings transformed into points from 1 to 4; one point for Poor and four for Very good:

- Very good – if the trunk bends until the chest touches the knee and the palms exceed entirely the toes;
- Good – if fingers exceed toes;
- Average – if fingers touch toes;
- Poor - if fingers did not touch toes.

The Matorin test evaluates coordination, spatial orientation capacity, balance, and rotation speed. It consists of a rotation in the air after a jump, first in the right and then in the left direction. The test is carried out by tracing a line of 35 cm on the ground, oriented in the north-south direction, and inscribed in an imaginary circle. The subject stands with the soles of each side of the line is required to jump and not to lose balance during the test and lands near the place and position as the starting point (Robertson & Fleming, 1987). The rotation is measured in degrees and the best attempt out of three was scored.

Ruffier test relay on measuring heart rate before and after performing 30 squads in 45 seconds (Joussellin, 2007). It estimates cardiovascular endurance and is based on heart rate in 3 moments: before effort (a resting HR1), post effort (HR2) over the first 15 seconds, and again 1 minute after the effort (HR3) over 15 seconds (Monea et al., 2017).

Ruffier Index (RI) formula is  $RI = (HR1 + HR2 + HR3 - 200) / 10$

Squads and sit ups in 30 seconds tests recorded the maximum number of correctly performed repetitions.

#### *Statistical analysis.*

Data was analysed using IBM SPSS Statistic 20 and Excel Microsoft 365 in displaying results in tables. The pre-pandemic group's results were compared with the post-pandemic one using t-tests, and the statistical significance was set at  $p < 0.05$ . Also, the effect size calculation demonstrated how substantially different are the two samples due to the long period of confinement.

## **Results**

Data were gathered by testing and recording results during physical education lessons as part of assesment methodology. In Bucharest University of Economic Studies physical education lessons for female students in the first year usually contain aerobic gymnastics and fitness. The testing took place in the gymnasiums where the students used to work out. The row data obtained by the two samples at six physical tests and the mean changes in students' physical potential before and after the pandemic

restriction are presented in Table 1, together with the Cohen effect size numerical results.

Test	Sit ups 30s		Flexibility		Standing long jump		Squats 30s		Matorin right side		Matorin left side		Ruffier test	
	B <sup>1</sup>	A <sup>2</sup>	B	A	B	A	B	A	B	A	B	A	B	A
1	13	21	2	3	1,71	1,6	16	16	415	380	405	410	10,2	13,1
2	15	8	3	3	1,60	1,6	16	16	420	350	315	400	10,4	8,3
3	14	20	2	1	1,59	1,47	10	13	430	340	405	360	11,5	9,5
4	16	11	4	1	1,69	1,28	18	14	320	300	360	400	7,3	10
5	25	18	4	3	1,65	1,79	24	19	315	350	460	380	8,5	12,2
6	25	13	2	4	1,65	1,43	22	18	425	310	315	410	12,4	14,4
7	25	15	4	1	1,65	1,59	20	18	360	320	360	390	8,1	8,5
8	25	16	2	2	1,81	1,64	22	14	360	340	405	350	9,5	15,4
9	20	11	4	3	1,99	1,58	25	11	360	330	360	380	8,2	11,5
10	19	17	4	4	1,75	1,73	18	22	315	350	315	410	9,4	8,1
11	19	15	4	3	1,75	1,55	18	23	360	460	360	520	7,3	14,5
12	20	16	4	3	2,01	1,59	25	18	360	340	360	350	8,2	12
13	25	19	2	1	1,8	1,82	22	23	410	380	475	430	10,2	8,5
14	25	13	4	1	1,85	1,5	20	19	450	300	450	340	8,1	14
15	25	11	2	1	1,65	1,29	22	13	350	330	460	380	12,4	13,1
16	25	10	4	2	1,65	1,46	24	12	315	290	435	380	7,1	11,5
17	16	20	4	3	1,70	1,72	18	24	415	350	450	300	8,5	9,8
18	14	18	2	2	1,60	1,45	10	16	345	310	430	340	9,4	13
19	25	21	3	3	1,90	1,62	16	22	480	320	515	310	11,5	10,2
20	13	17	2	2	1,70	1,56	16	18	320	310	405	350	10,4	12,4
21	22	9	3	1	1,75	1,41	20	12	460	290	390	320	9,5	13,5
22	23	15	3	2	1,85	1,55	21	16	440	280	450	360	11,9	12,4
23	24	16	4	2	1,80	1,62	19	18	510	310	540	380	10,9	11
24	20	18	3	2	1,90	1,68	21	21	480	320	480	370	9,2	10,2
25	18	13	3	2	1,85	1,51	18	15	460	310	455	310	12,1	13,8
X	20,44	15,24	3,12	2,2	1,75	1,56	19,24	17,24	394,2	330,8	414,2	373,2	9,68	11,63
SD	4,48	3,78	0,88	0,95	0,12	0,13	3,93	3,77	58,87	37,4	61,1	46,2	1,65	2,14
Effect size	1,25		3,16		1,51		0,52		0,152		0,75		0,56	

Table 1: Two sample results; B1= before pandemic; A2= after pandemic

Based on the mean and standard deviation, the effect size was calculated and compared with Cohen effect size index where  $d=0,2$  is considered small;  $0,5$  medium;  $0,8$  large and  $1,3$  very large (Sullivan & Feinn, 2012). As it can be seen the lack of physical activity impacted the most the abdominal strength (sit ups), flexibility and lower body power (standing long jump).

In Table 2 are displayed the summary of two paired sample t-test (two tails) and the range of the effect size.

Variables	Mean	Std. Deviation.	Std. Error Mean	t-test	df	Sig. (2-tailed)	Cohen
Abs 30s	5,2	6,39	1,278	4,069	24	,000	Large
Flexibility	0,92	1,18743	0,237	3,874	24	,001	Very large
Standing long jump	0,1924	0,15431	0,030	6,234	24	,000	Very large
Squad 30s	2	5,61991	1,123	1,779	24	,088	Medium
Matorin l.	72	94,89029	18,978	3,794	24	,001	Small
Matorin r.	70,6	150,0717	30,014	2,352	24	,027	Medium
Ruffier	-1,948	2,57231	0,514	-3,786	24	,001	Medium

Table 2: Paired Samples Test

Only in the case of squads in 30s, the difference between the two samples is not statistically significant. In all other tests, results (calculated  $t >$  tabular  $t$ ) show a statistically significant difference, confirming the hypothesis that the two samples differ in strength, power, flexibility, coordination, and cardio-respiratory fitness. For  $df=24$   $t$  critical= $2,06$   $p<,05$ .

## Discussions

In sit ups test was found a significant difference ( $p<,000$ ) between the two groups, the decrease for the post-pandemic sample being in average 5 reps, representing 25 percent from the base line value. On the other strength test squats in 30s the results decrease was moderate, just of two reps and consequently the difference was not statistically significant, but the effect size was large ( $d=0,52$ ). Other studies also observed that in the first months after the resumption of classes the strength performances of female students was 34% lower than before confinement (Carriedo et al., 2022). Strength exercises ensure a correct body posture and have beneficial morphological and functional transformations (Jorgić et al., 2024)

Flexibility lost the most of all the measured physical abilities, almost 30 percent. Moreover, the size effect (3,16) indicates that the two groups'

results differ by 3 standard deviations. While the Average values remained at the same level, the most significant drop was from the best rating before pandemic to the lowest after lockdown. Comparing our data with an extensive study on Chinese university students (Table 3) with the same test, and same kind of assessment (Ripley-Gonzalez et al., 2023) will observe that flexibility requires attention in recovery and improvement for our students because more than one quarter performed poorly.

Rating	China study	2020 sample	2022 sample
Very good	21%	44%	8%
Good	25,4%	24%	32%
Average	55%	32%	32%
Poor	1,8%	0	28%

Table 3 Sit and reach comparison.

In standing long jump the results obtained in our samples are 1,75m and respectively 1,56m. The lower body explosive power decrease pre-versus post-pandemic is of 19 cm, representing 10,8 percent drop. The comparison with reference data for girls over 16 years (Hede, 2011) (Table 4) confirms the negative evolution in fitness level. While in the first sample the 1,75m performance is rated as Average, the second result of 1,56m is Below average. These findings are confirmed by other studies in which same trend (Ripley-Gonzalez & et al., 2023) and close values were obtained for this test (Pop et al., 2023). Also, the effect size is in the extensive range.

Slj Values	Rating
>1.91m	Excellent
1.78-1.90m	Good
1.77-1.63m	Average
1.50-1.62m	Below average
<1.50m	Poor

Table 4 Standing long jump ratings

At the first glance Matorin test results have better values for rotation to the right than to the left side. A complete rotation of  $360^{\circ}$  is considered a very good outcome. There is a significant difference between the pre and post-pandemic sample results  $t_{(24)}\text{left}=3,8$   $p<,001$ ;  $t_{(24)}\text{right} = 2,35$   $p<,027$ . Overall, the drop in this test is 13%.

Ruffier index was calculated and compared with cardio-vascular endurance ratings (Wood, 2019) Ruffier index: less than 0 - Excellent;  
0-3 -Very good 3-6 - Reasonably good

6-9 – Average 9-12 – Average  
12-15 – Poor 15 and up – Very poor

Cardiorespiratory fitness is a marker of physical health, which indicates the capacity of the two systems to provide the oxygen needed for the energy supporting the physical activity (Wang et al., 2023). Cardiorespiratory fitness ensures not only physical resilience but also resistance to stress, preventing or alleviating various health problems and is found to be in close connection with academic performance (Honório et al., 2024).

The data analysis showed that both samples are in the moderate range of cardio-vascular endurance, between 9 and 12. The difference between the two samples consists of position in this interval: while the first is in the Average range proximity (9,68), the second in near the Poor values (11,63). Those almost 2 points make a significant difference:  $p < ,001$ . In percentages, the difference between the two samples is of 16.7% and the effect size is moderate ( $d=0,56$ ) too.

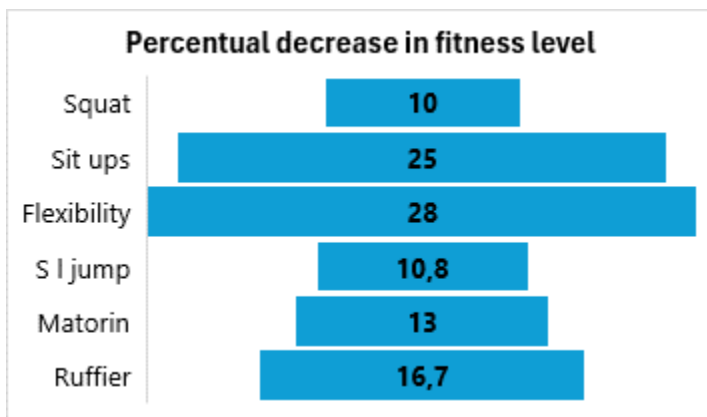


Chart 1. Percentage decrease in fitness level

Chart 1 illustrates to which extent physical capacity was affected by the restrictions during the pandemic in the post-confinement sample. The most important decrease can be seen in flexibility and abdominal straight and endurance. The explosive power and muscular strength of the legs had the least losses in performance. Even though lowering in coordination and cardio fitness were recorded, the post-pandemic results remain in the moderate range.

In relative opposition with Muzyka et al. (2023), whose study concluded the high effectiveness of distance learning, the present research outcomes demonstrated that in formal physical education, the pedagogical

direct interaction seems to have better results. One of the valuable lessons after lockdowns is teachers' awareness regarding the changing student's needs and interests related to physical activity. Mandatory isolation measures negatively impacted the physical activity, body mass index, and sitting habits of the university community (Hurtado Montes, 2023).

The future work place for will integrate teleworking, digitalisation of processes, robotics and management softwear, all of this requiring screen hours in sitting position. To compensate for these working conditions and to mitigate physical inactivity a salient PE teachers' goal is to promote vigorous physical activity, organise amateur sports competitions, or cultivate the students' habit to comply with the WHO (WHO, 2024) recommendations: at least 150-300 minutes of moderate intensity throughout a week.

*Limits of the study.* One limitation of the study is that there were differences between countries regarding the length and severity of the sanitary restrictions adopted during the Covid-19 pandemic. Therefore, there could be differences between the negative consequences of cumulative sedentary activities determined by the confinement in parallel with different results in the fitness level of population segments.

A limitation common in most of investigations is the sample size which could be more numerous, but given the apprehension caused by the contagion of the virus and then the suspension of university courses in March 2020 limited the number of tested subjects. The homogeneity of gender and age compensates partially for the samples small size.

*Future research directions.* A future research hypothesis would be that all the generations that experienced two years of quarantine and reduced physical activity would continue to have a lower level of fitness compared with the generation graduated before COVID-19 restrictions. More extensive investigations are needed to estimate the comprehensive impact and long-term implications, as well the necessary time and proper methods to recover the students' fitness at the level recorded before pandemic outbreak.

## Conclusions

Data confirms the research hypothesis: physical abilities decrease was between 10 and 28 percent. The most worrying level was recorded at flexibility and abdominal strength, on which the effect size was very large and large respectively. The strength of this study is the comparison of objective fitness tests in two successive young women samples that can contribute to a more complete understanding of the long-term impact of the pandemic breakdown. The actual generation of students is the future educated workforce, and a diminished physical potential would have lasting effects on

their physical and mental health with higher healthcare expenditure and lower productivity due to a decrease in workforce quality and resilience.

Remedial measures are needed to reverse the physical potential decrease of young adults after the sanitary crisis. The practical application of our study would follow three directions: Adaptation to the current physical potential of confinement afflicted generation; Rehabilitation of the fitness level where the pandemic disrupted it, and Prevention by combining physical education and health knowledge.

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