COMPARATIVE STUDY OF AEROBIC CAPACITY IN FEMALE STUDENTS BEFORE AND AFTER THE COVID-19 PANDEMIC

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Abstract. *In December 2019, the first cases of COVID-19 appeared in China, and the virus spread rapidly all over the world. In this context, Romanian public authorities implemented specific social distancing measures to prevent or slow down the transmission of the virus, imposing quarantine (16 March to 14 May 2020), travel restrictions, closure of educational institutions and certain work sectors, and banning artistic and sports events. Research has highlighted changes in the lifestyle of the entire population during the COVID-19 pandemic through the emergence of unhealthy behaviours, including among university students worldwide. According to the World Health Organization, physical inactivity is one of the most important risk factors for various diseases, hence its recommendations for adult people to do at least 150 minutes of moderate-intensity aerobic physical activity per week. These recommendations for weekly physical activity were often not fulfilled during the pandemic, especially in lockdown periods, as shown by numerous studies conducted on samples of different nationalities. This research aims to emphasise the status of aerobic endurance in female students after attending exclusively online courses for 21 months. The research was conducted at the Politehnica University of Bucharest, and the participants were 125 young women aged 19-21 from the pre- and post-pandemic generations. The assessment was indirectly performed through the 2-Km Walk Test with the purpose of outlining possible gaps between the two generations. Analysing the research results, we could conclude that the pandemic had an impact on raising awareness of the need for movement among young women.*

Keywords: *aerobic capacity, aerobic fitness, COVID-19 pandemic, university students, 2-Km Walk Test.*

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Introduction

In December 2019, the first cases of COVID-19 appeared in China, and the virus spread rapidly all over the world (Zhou et al., 2020), so the World Health Organization (WHO) (2020) declared the outbreak of SARS-CoV-2 as a pandemic event on 11 March 2020.

Following the emergence of the first cases of coronavirus in Romania in February 2020, the rapid increase in the number of people infected with SARS-CoV-2, the lack of information about this novel virus and the lack of appropriate medical infrastructure to deal with this pandemic, Romanian public authorities implemented specific social distancing measures to

prevent or slow down the transmission of the virus, imposing quarantine (16 March to 14 May 2020), travel restrictions, closure of educational institutions and certain work sectors, and banning artistic and sports events.

In this new context, the COVID-19 pandemic has disrupted and changed the patterns and habits of the common lifestyle. The pandemic situation has also created significant disruptions in education activities around the world, including academic activity, generating the abrupt transition to digital learning after the lockdown (Webb et al., 2021) imposed as a measure to limit SARS-CoV-2 coronavirus infection among the population.

The COVID-19 pandemic has led to an acute need for the use of technology in education, the digitalisation of teaching methods and pedagogies and the provision of infrastructure required for inclusive and resilient distance learning (European Commission, 2020).

All these aspects had repercussions on the educational process (Buzatu et al., 2020) but also on the lifestyle of young people in the university environment, requiring a prompt response from the university management to ensure the continuity of the educational process in an online format corresponding to the academic teaching standards (Butnaru et al., 2021).

The Politehnica University of Bucharest (UPB), as the largest technical higher education institution in Romania, took the initiative to conduct online courses since 12 March 2020 on the already existing Moodle platform and then on Microsoft Teams in order to prevent a crisis generated by a possible infection of teachers and the approximately 25,000 students enrolled at the university in all study cycles. The teaching activity in an exclusively online format continued at UPB until November 2021, when a hybrid teaching system was adopted.

Several studies have highlighted changes in the lifestyle of the entire population during the COVID-19 pandemic through the emergence of unhealthy behaviours (Ruíz-Roso et al., 2020) (physical inactivity, unbalanced diet, increased alcohol and cigarette consumption, irregular sleep patterns), which have a great influence on maintaining good health (Lange & Nakamura, 2020).

Following the total lockdown and social distancing measures taken by public authorities, sedentary behaviour, which is closely related to the occurrence of cardiovascular risk factors and higher morbidity rates (Young et al., 2016), increased during the COVID-19 pandemic among both children, young people (Elnaggar et al., 2020; Ning et al., 2020) and the adult population, despite the tips provided by specialists (Izzicupo et al., 2020).

Thus, the data provided by 3052 US adults (from all 50 states) between 3 and 8 April 2020 revealed that physical activity was 32% lower post-COVID among participants who had previously been active but largely remained unchanged among previously inactive participants, which "was associated with higher depressive and anxiety symptoms" (Meyer et al., 2020). A survey conducted by Wang et al. (2020) on 2289 Chinese adults (mean age: 27.8 +/- 12 years) highlighted that only 20% of respondents reported engaging in daily moderate-to-vigorous physical activity during a period of isolation at home for 77 days on average.

A survey of the French population, which collected data from 4005 people after the lockdown implementation, reported unhealthy lifestyle changes and lack of physical activity, especially in the male gender (Constant et al., 2020).

A 32.4% decrease in physical activity was equally observed among the Japanese population aged 40-69 between October 2019 and April 2020 (Makizako et al., 2021).

Another study (Ammar et al., 2020) conducted on 1047 respondents from Asia, Africa and Europe emphasised a decrease in physical activity during the COVID-19 pandemic and an increase in sedentary behaviour by more than 28%. Also, Woodruff et al. (2020) investigated the step counts of the Canadian population during the pandemic and found low levels of physical activity and increased screen times, which were associated with higher daily stress.

All these data aroused our curiosity to examine the status of aerobic exercise capacity among UPB female students following the courses delivered exclusively online for 21 months and to identify possible gaps between pre- and post-pandemic generations.

The research *purpose* is to highlight the status of aerobic exercise capacity in female students before and after the pandemic, following the restrictions imposed during this period and the exclusively online course attendance.

Methodology

Participants and Procedure

The research participants were 125 female students aged 19-21 years from the Politehnica University of Bucharest (UPB). The group of students tested before the pandemic (G1) consisted of 49 participants, and after resuming face-to-face classes, group 2 (G2) was made up of 76 participants.

It was resorted to the use of two samples of participants because it was not possible to use the same sample, the girls consenting to the use of personal data, but not to a new support of the physical test, no longer having physical education lessons. In the two samples of the study were included only non-athletic students, from the first year, of normal weight, who participated in the physical education and sports lessons, the groups being, therefore, equivalent. All of the students were healthy and had no medical conditions that might have worsened during the tests. Before the experiment, all students were explained the test procedures and ways of assessment, and their informed consent was obtained.

The research took place at the UPB Sports Complex from October 2019 to March 2022.

Research methods

The research methods used in this study were: scientific documentation, experiment, graphical method and mathematical statistics method.

For the statistical calculations, the t-Test for Two Independent Samples was used to verify whether there were statistically significant differences between the results achieved by two groups for an investigated characteristic (Predoiu, 2021) but also Levene's Test. The calculations were performed using the Statistical Package for the Social Sciences (SPSS).

Aerobic (cardiorespiratory) capacity or aerobic fitness was assessed by the 2-Km Walk Test, which is simple, accessible, risk-free and very effective for measuring this parameter.

The test involves walking as fast as possible over 2 km, and the equipment required consists of a stopwatch and record sheets for information such as age, height, heart rate, etc.

The score obtained in this test was calculated taking into account:

1. The walking time taken to cover the 2 km

2. Heart rate at the end of the walk
3. Body mass index
4. Age

The results obtained represent the aerobic fitness index (FI), which is calculated based on the participant's height, weight, gender, age, walking time and heart rate.

The aerobic fitness index obtained must be compared with the following scale:

- below 70 = poor FI
- 70/89 = below-average FI
- 90/110 = average FI
- 111/130 = good FI
- above 130 = very good FI

Heart rate was monitored with the help of pulse oximeters, which is why female students had been asked not to have their manicure done at the time of the test for better accuracy in heart rate recording. At the end of the test, the record sheets were completed for all participants by entering their age, walking time over the 2 km, heart rate, height and weight.

Before starting the test, the girls performed warm-up exercises for about 15-20 minutes.

Results

The results obtained in the tests performed before the pandemic (G1) and after resuming face-to-face classes (G2) are shown in the following tables.

Table 1. *Group Descriptive Statistics*

FI	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance	Std. Error
Before COVID	49	69	81	150	107,08	20,11	404,58	2,87
After COVID	75	70	73	143	110,07	17,44	303,98	2,01

Table 2. *Independent Samples t-Test*

Equal variances	Levene's Test for Equality of Variances		t-Test for Equality of Means						
	F	Sig.	t	Df	P	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Assumed	1.320	0.251	0.877	122.000	0.382	-2.985	3.405	-9.725	3.755
Not assumed			0.851	92.270	0.397	-2.985	3.509	-9.953	3.983

The average aerobic fitness index of students of the two groups is lower by 2.99 (2.8%) for G1 (before COVID) compared to G2 (after COVID). The average scores obtained by the two groups are 107.08 for G1 and 110.07 for G2 (Table 1).

According to Levene's Test for Equality of Variances (Table 2), the two groups have similar dispersion, Sig. = 0.251 > 0.05 for F = 1.332. The Independent Samples t-Test for Equality of Means shows a statistically insignificant mean difference, with p = 0.382 > 0.05 for t = 0.877 and df = 122.

The average aerobic FI scores for the two groups are shown in Figure 1.

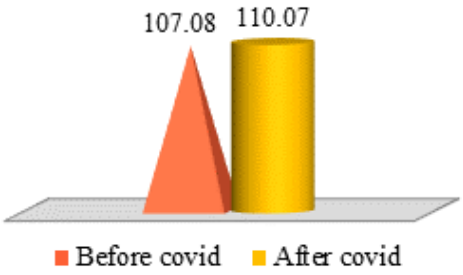

Figure 1. Average aerobic FI scores for the two groups (G1, G2)

Table 3. *Group Descriptive Statistics*

Period	N	Mean	Std. Deviation	Std. Error Mean
Before COVID (G1)	9	85.22	2.728	0.909
After COVID (G2)	8	81.63	5.476	1.936

Table 4. *Independent Samples t-Test for students with below-average FI levels*

Equal variances	Levene's Test for Equality of Variances		t-Test for Equality of Means						
	F	Sig.	T	Df	P	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Assumed	3.392	0.085	1.747	15	0.101	3.60	2.059	-0.792	7.987
Not assumed			1.682	10.004	0.124	3.60	2.139	-1.168	8.363

The average aerobic fitness index for students with below-average levels is higher by 3.60 (4.2%) for G1 (before COVID) compared to G2 (after COVID). The average scores obtained by the two groups are 85.22 for G1 and 81.63 for G2 (Table 3).

According to Levene's Test for Equality of Variances (Table 4), the two groups have similar dispersion, Sig. = 0.085 > 0.05 for F = 3.392. The Independent Samples t-Test for Equality of Means shows a statistically insignificant mean difference, with p = 0.101 > 0.05 for t = 1.747 and df = 15.

The average aerobic FI scores for the two groups with below-average levels are shown in Figure 2.

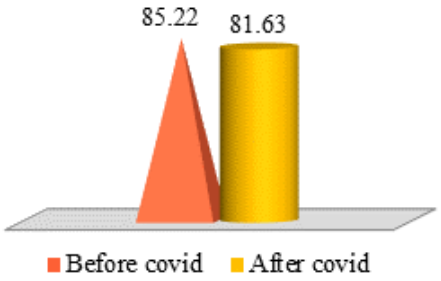

Figure 2. Average aerobic FI scores for the two groups with below-average levels

Table 5. *Descriptive Statistics for students with average FI levels*

Period	N	Mean	Std. Deviation	Std. Error Mean
Before COVID	22	97.64	5.551	1.183
After COVID	32	100.22	6.791	1.200

Table 6. *Independent Samples t-Test for students with average FI levels*

Equal variances	Levene's Test for Equality of Variances		t-Test for Equality of Means						
	F	Sig.	T	Df	P	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Assumed	2.912	0.094	1.476	52	0.146	-2.58	1.750	-6.094	0.930
Not assumed			1.532	50.342	0.132	-2.58	1.686	-5.968	0.803

The average aerobic fitness index for students with average levels is lower by 2.58 (2.6%) for G1 (before COVID) compared to G2 (after COVID). The average scores obtained by the two groups are 97.64 for G1 and 100.22 for G2 (Table 5).

According to Levene's Test for Equality of Variances (Table 6), the two groups have similar dispersion, Sig. = 0.094 > 0.05 for F = 2.912. The Independent Samples t-Test for Equality of Means shows a statistically insignificant mean difference, with p = 0.146 > 0.05 for t = 1.476 and df = 52.

The average aerobic FI scores for the two groups with average levels are shown in Figure 3.

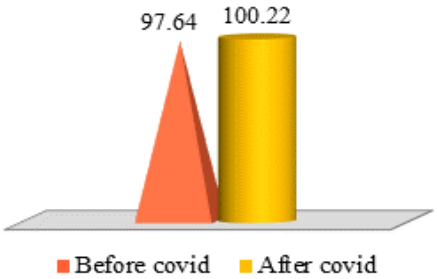

Figure 3. Average aerobic FI scores for the two groups with average levels

Table 7. *Descriptive Statistics for students with good FI levels*

Period	N	Mean	Std. Deviation	Std. Error Mean
Before COVID	10	118.20	5.453	1.724
After COVID	24	120.21	4.809	0.982

Table 8. *Independent Samples t-Test for students with good FI levels*

Equal variances	Levene's Test for Equality of Variances		t-Test for Equality of Means						
	F	Sig.	T	df	p	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Assumed	0.612	0.440	1.067	32	0.294	-2.01	1.881	-5.841	1.824
Not assumed			1.012	15.156	0.327	-2.01	1.984	-6.234	2.217

The average aerobic fitness index for students with good levels is lower by 2.01 (1.7%) for G1 (before COVID) compared to G2 (after COVID). The average scores obtained by the two groups are 118.20 for G1 and 120.21 for G2 (Table 7).

According to Levene's Test for Equality of Variances (Table 8), the two groups have similar dispersion, Sig. = 0.440 > 0.05 for F = 0.612. The Independent Samples t-Test for Equality of Means shows a statistically insignificant mean difference, with p = 0.294 > 0.05 for t = 1.067 and df = 32.

The average aerobic FI scores for the two groups with good levels are shown in Figure 4.

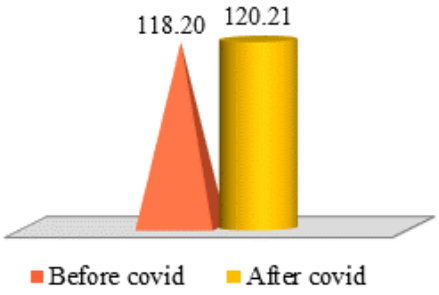

Figure 4. Average aerobic FI scores for the two groups with good levels

Table 9. *Descriptive Statistics for students with very good FI levels*

Period	N	Mean	Std. Deviation	Std. Error Mean
Before COVID	8	143.75	5.203	1.840
After COVID	11	137.27	3.717	1.121

Table 10. *Independent Samples t-Test for students with very good FI levels*

Equal variances	Levene's Test for Equality of Variances		t-Test for Equality of Means						
	F	Sig.	T	df	P	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Assumed	5.504	0.031	3.175	17	0.006	6.48	2.040	2.173	10.781
Not assumed			3.007	12.004	0.011	6.48	2.154	1.784	11.170

The average aerobic fitness index for students with very good levels is higher by 6.48 (4.5%) for G1 (before COVID) compared to G2 (after COVID). The average scores obtained by the two groups are 143.75 for G1 and 137.27 for G2 (Table 9).

According to Levene's Test for Equality of Variances (Table 10), the two groups does not have similar dispersion, Sig. = 0.031 < 0.05 for F = 5.504. The Independent Samples t-Test shows a statistically significant mean difference, with p = 0.011 < 0.05 for t = 3.007 and df = 12. The effect size index shows that the mean difference is very large.

The average aerobic FI scores for the two groups with very good levels are shown in Figure 5.

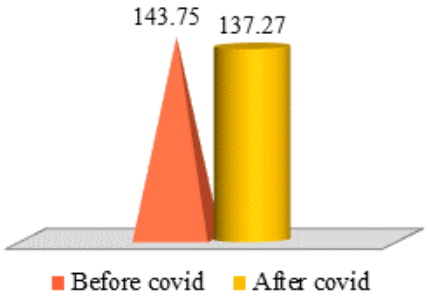

Figure 5. Average aerobic FI scores for the two groups with very good levels

Discussion and Conclusion

It is known that all unhealthy behaviors are associated with decreased body function and increased risk of potential disease (Saunders et al., 2020; Katzmarzyk et al., 2019).

According to the World Health Organization (2010), physical inactivity is one of the major risk factors for various diseases (being responsible for 6% of deaths globally), hence its recommendations for adult people to do at least 150 minutes of moderate-intensity aerobic physical activity per week.

The WHO recommendations on weekly physical activity were often not fulfilled during the pandemic, especially in lockdown periods, as shown by numerous studies conducted on samples of different nationalities.

Castañeda-Babarro et al. (2020) studied a sample of 3800 healthy adults (aged 18-64) and found that vigorous physical activity and walking time had decreased by 16.8% and 58.2%, respectively, while sedentary time had increased by 23.8%; thus, the percentage of people

fulfilling the recommendation for 75 minutes per week of vigorous physical activity decreased by 10.7%. Similar results were revealed by the study of Qin et al. (2020) on a sample of 12,107 participants aged 18-80, showing that over 60% of Chinese adults had inadequate physical activity, while their average screen time exceeded 4 hours a day (261.3 +/- 189.8 min a day).

Unhealthy behaviours were also found in the Lithuanian population over the age of 18, whose physical activity decreased by 60%, which resulted in a weight gain of 31.5% for every third respondent during lockdown (Kriaucioniene et al., 2020).

A decline in physical activity was noted among overweight and obese people aged 18-35, although some were engaged in weight loss programmes (Lawhun Costello et al., 2021).

Young Iranian adults aged 29.24 ± 9.5 years experienced a decrease in physical activity levels during the pandemic compared to the pre-pandemic period, 78% of participants failing to comply with the physical activity guidelines (Amini et al., 2020).

Less physical activity was also observed in university students of both genders from many countries, with "30% fewer Australian students achieving 'sufficient' levels of activity, defined by at least 150 min over at least five sessions, compared with the previous two years" (Gallo et al., 2020).

Physical activity levels before and after 30 days of restrictions due to the pandemic were investigated by Karuc et al. (2020) on 91 young adults aged 20-21, the authors finding a decline in their moderate-to-vigorous physical activity (64.8 min per day for females and 57.7 min per day for males). Interestingly, the same study found that non-active participants had increased their moderate-to-vigorous physical activity levels by 48.9 min per day. Similar results were obtained by Romero-Blanco et al. (2020) who conducted a survey among health sciences students during lockdown and reported increases in moderate and vigorous physical activity levels (71.6% and 7.4%, respectively).

For Polish university students, the lockdown period had statistically insignificant effects on physical activity and body composition (Bielec & Omelan, 2022).

The closure of universities and the cancellation of face-to-face physical education classes due to the COVID-19 pandemic decreased the overall physical activity, fitness levels and academic performance of all students (Osipov et al., 2021).

During the COVID-19 pandemic, low levels of physical activity were also found among university students from Slovakia (Líška et al., 2021) and Italy (Luciano et al., 2021).

Croatian medical students experienced a decline in physical activity and high levels of depression, anxiety and stress during the second partial lockdown (Škrlec et al., 2021).

The study conducted by Lukács (2021) on 2779 Hungarian students (mean age 24.52 years) to investigate their levels of moderate and vigorous physical activity showed that they has been negatively influenced by the closure of universities.

In Romania, a study carried out by Leuciuc et al. (2020) on a sample of university students revealed that two thirds (according to the IPAQ scoring protocol) or more than half of them (according to the WHO recommendations on physical activity) considered themselves to be active, although female students were less active than their male counterparts.

According to Kıvrak (2021), no statistically significant differences were found in the physical activity of 495 Turkish students during the pandemic because they maintained an active lifestyle; however, females had higher scores than males for walking and total MET.

The results of our study revealed no significant differences in the aerobic fitness of the pre-pandemic generation compared to the generation of girl students affected by pandemic restrictions, which involved attending exclusively online courses. This was probably due to sedentary behaviour of our students, which was highlighted in studies conducted by the Physical Education and Sports Department of the UPB (Wesselly et al., 2018).

Comparing the aerobic fitness indices achieved by the two groups for each level of the scale, significant differences were found only between young women with a very good aerobic fitness index, the mean scores of the two groups being 143.75 for the pre-pandemic generation and 137.27 for female students who participated in online courses.

The limitation of the current study could be the tendency of some participants to switch from walking to running or not to cover the distance of 2 km at a fast pace in relation to their own exercise capacity.

The results of this study are consistent with those of other studies in the literature (Bielec & Omelan, 2022; Romero-Blanco et al., 2020; Kıvrak, 2021).

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Informed Consent Statement: The participants provided their written informed consent to participate in this study.

Data Availability Statement: Data are available upon request to the contact author.

Conflicts of Interest: The authors declare no conflict of interest.

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