Clinical Medicine

Physical Activity Level Alterations Due to the Lockdowns: A Multi-Center Greek University-Based Study

Konstantinos Natsis[1], Michael Kostares[2, a], George Tsakotos[2, a], Christos Koutserimpas[2, 3], Evangelos Kostares[2], George Triantafyllou[2], Trifon Totlis[1], Vasilios Karampelias[2], Dimitrios Chytas[4], Nikos Pantazis[5], Nikos Otountzidis[1], Anastasia Triantafyllou[2], Vlassis Achlatis[1], Vasilios Ediaroglou[1], Maria Piagkou[2]

[1]Department of Anatomy, Faculty of Health Sciences, School of Medicine, Aristotle University of Thessaloniki, Greece, [2]Department of Anatomy, School of Health Sciences, School of Medicine, National and Kapodistrian University of Athens, Greece, [3]Department of Orthopedics and Traumatology, "251" Hellenic Air Force General Hospital of Athens, Greece, [4]Basic Sciences Laboratory, Department of Physiotherapy, University of Peloponnese, Sparta, Greece, [5]Department of Hygiene, Epidemiology, and Medical Statistics, Medical School, National and Kapodistrian University of Athens, Greece, [6]Department of Neurosurgery, Aristotle University of Thessaloniki, Greece

Correspondence: *gtsakotos@gmail.com*; Tel.: + 30 69 77601081

Received: 9 May 2023; Accepted: 28 August 2023

Abstract

Objective. This cross-sectional study determines the impact of the pandemic lockdowns on physical activity, and evaluates the factors associated with physical activity cessation on students and personnel of eight Greek Higher Education Institutions. **Materials and Methods.** A total of 6,380 volunteer participants completed a survey reporting their physical activity levels and perceptions during the COVID-19 pandemic. The survey was made available through an online platform. **Results.** Both the conduct and intensity of physical activity were significantly reduced from the pre-pandemic era to the second lockdown (P<0.001). Walking was the most frequently selected type of physical activity, in all periods except for the second lockdown. Loss of interest (52.4%) was the main, self-reported factor for cessation of physical activity. Females had a 31% lower probability of ceasing physical activity during lockdowns. **Conclusion.** The conduct and intensity of physical activity decreased significantly during the pandemic. Female gender, annual checkup attendance, and specific physical activity types during the pre-pandemic era were associated with a reduction in the risk of pausing physical activity during lockdowns. Lockdowns may be implemented in future health crises, hence measures for maintaining the physical activity of the general population, such as online group sessions and support from healthcare professionals, should be prepared.

Key Words Exercise ▪ Survey ▪ Pandemic ▪ Musculoskeletal Health.

Introduction

Following the declaration of the COVID-19 pandemic by the World Health Organization (WHO) on March 11, 2020 (1), various restrictive measures were put in place to curb the spread of the SARS-CoV-2 virus. These measures included the cancellation of mass gatherings, the closure of public areas, and the mandatory use of protective masks. The first infection in Greece was recorded on February 26th, 2020, and from then, the Greek

government implemented strict preventive measures in good time, including two national lockdowns, to prevent the spread of the coronavirus (2). The main concern in Greece was the endurance of the aged national health system under the pressure of the country-level epidemic. A depiction of the COVID-19 pandemic timeline in Greece is presented in Figure 1. This confinement may have led to several modifications in everyday activities that might have eventually resulted in the adoption of sedentary behavior, predisposing to a variety of diseases, such as obesity, and cardiovascular
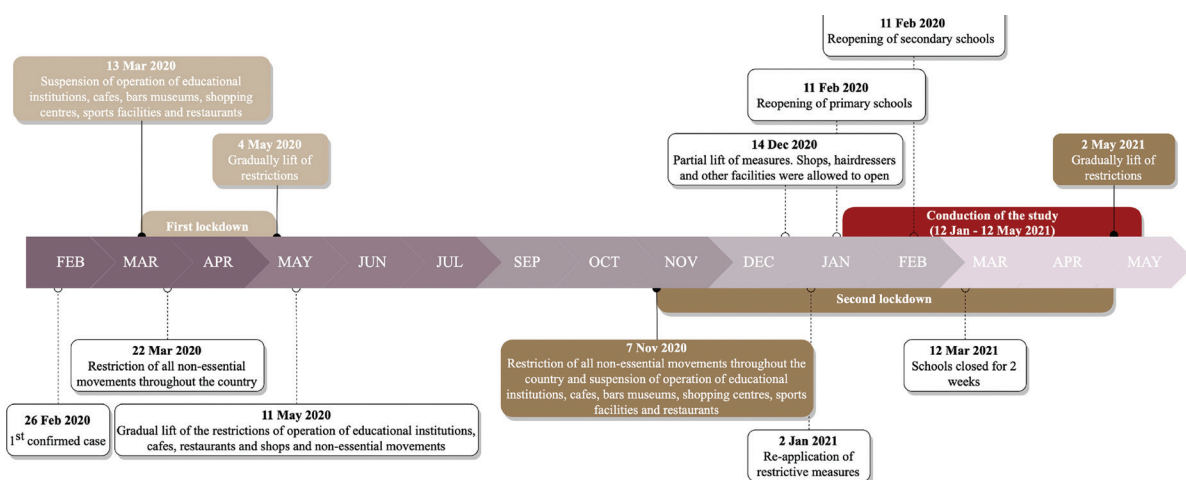
---

[a] Authors' equal contribution

Figure 1. The COVID-19 pandemic timeline in Greece.

and osseous diseases (3, 4). Regardless of the levels of physical activity (PA), recent research suggests a correlation between sedentary behavior and mortality (5-11). Additionally, excessive sedentary behavior and a lack of PA are connected to psychological distress and mental health disorders, including depression (12, 13).

The current questionnaire-based multi-center study aimed to record the alterations in PA levels in Greece during the pandemic-related lockdowns, and to identify the factors associated with physical inactivity.

Materials and Methods

Study Design

From January 12, 2021, to May 12, 2021, a cross-sectional multi-center study was conducted in Greece. The study involved students and personnel from eight Greek Higher Education Institutions. A total of 26 Institutions were invited to participate, and 8 out of 26 (30.8%) agreed. The collaborating Institutions posted an announcement on their official website, which included details about the study and a link to the questionnaire. Any adult over 18 years who was involved with any of the collaborating Greek Highest Education Institutions on an academic or occupational level was considered eligible, regardless of gender, academic year, full-time/part-time employment, or academic program.

Questionnaire Development

The questionnaire consisted of 34 questions, with each question representing a different study variable. The questions were divided into 4 domains. Prior to beginning the study, the questionnaire underwent testing for validity and completeness. On the basis of input from expert academics who were not involved in the study, changes were made to improve it. The first set of questions focused on standard sociodemographic factors, including age, gender, height (in centimeters), weight (in kilograms with no decimal approximation), living conditions (living with others, number of household members, and permanent residency), educational attainment, employment status, and smoking habits. For the study purposes, smoking was defined as having smoked at least one cigarette every 1-3 days for six months. Former smokers were those who had quit tobacco for at least a year, while occasional smokers fell between these two categories. Alternatives such as IQOS° or electronic cigarettes were also available as options. For all former smokers, the duration of smoking cessation (in months) was also required. The second domain was related to the participants' health status. Questions related to any history of underlying diseases (occurrence and type of disease), the effect of the diseases on performing PA (restriction), and the preventive measures taken for participants with such diseases (advice from a physician about PA and regular follow-up attendance). The third

domain was related to the participants' PA level. PA was defined according to WHO recommendations for adults aged between 18–64 years as the conduct of at least 150 minutes of moderate-intensity PA per week (14). The participants were asked to report information regarding their PA engagement (yes or no), the frequency (average number of times within a week), and the type of PA in four distinct periods: during the pre-pandemic era, the first lockdown, between the lockdowns, and during the second lockdown. The fourth and final domain contained 4 Likert-scale questions related to the participants' perspective regarding the relationship of the pandemic with PA. A sample of the questionnaire is provided in the Supplementary material.

Data Collection

The questionnaire was made available to the participants via the Google Forms platform (Google LLC, United States) by creating a separate link for each of the participating Greek Higher Education Institutions. Since the present study was conducted on a voluntary and anonymous basis, no emails or other personal data of the respondents were collected. However, double replies from the same participant were prevented by activating the "limiting replies" to a once-per-person function in Google Forms. The total number of individuals associated with these 8 Greek Higher Education Institutions and hence, those who could access and complete the questionnaire, was calculated to be 121,065 (110,514 students, 6,409 academicians, and 4,142 administrative officers). Incomplete questionnaires were not considered eligible. During the questionnaire's availability (a 5-month period - January to May 2021), a total of 6,380 valid questionnaires were gathered (5.3%). A map chart displaying the administrative regions that were declared as the respondents' permanent residences, and the frequency of replies per Higher Education Institute is presented in Figure 2.

Ethics Statement

The study was approved by the Ethics Committees of the National and Kapodistrian University of Athens, Greece, and the Aristotle University of Thessaloniki, Greece (N/2020/0567). The research was conducted following the principles of the 1964 Declaration of Helsinki and its later amendments.

Statistical Analysis

Statistical analysis was performed with the STATA statistical software (Release 14.0, Stata Corp., TX, USA) for macOS. The Shapiro–Wilk test, the evaluation of skewness and kurtosis values, as well as the visual interpretation of the histograms produced were used to assess data normality. In the case of normally distributed quantitative variables, mean and standard deviation (SD) values were used, otherwise, the median and interquartile range (IQR) were provided. All qualitative variables, except smoking cessation, were translated into categorical ones. The ages were subdivided into 5 groups (group 1: 18-24 years, group 2: 25-34 years, group 3: 35-44 years, group 4: 45-54 years, and group 5: 55-64 years), the height and weight into BMI levels (underweight: BMI score <18.5 kg/m^2, normal weight: BMI between 18.5 and 24.9 kg/m^2, overweight: BMI between 25.0 and 29.9 kg/m^2 and obese: BMI >30.0 kg/m^2), and the PA frequency into two PA intensity categories (irregular:< 5 days/week, and regular: ≥ 5 days/week). All qualitative variables were expressed in absolute (N) and relative (%) values. To compare ratios, Pearson's Chi-square test or Fisher's exact test were used for unpaired, and McNemar's test for paired data. The student's t-test was used to compare smoking cessation between the two groups. A stepwise multiple logistic regression analysis was conducted to investigate independently associated factors with the likelihood of ceasing the PA conduct during the pandemic. Adjusted odds ratios with 95% confidence intervals were computed from the results of the logistic regression analysis. Statistical significance was set at 0.05.
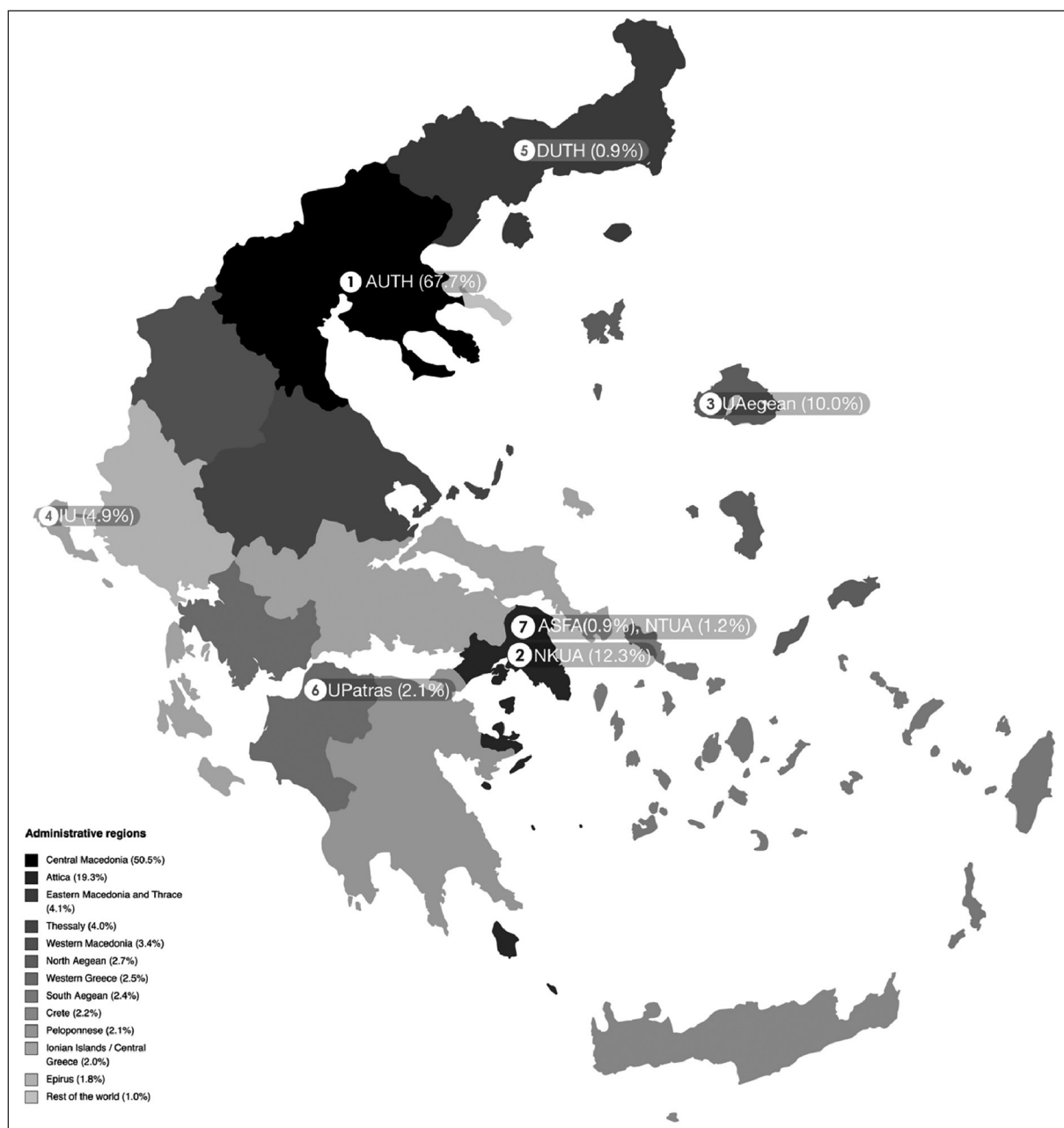
Figure 2. The mapping of the respondents per area in Greece.

Results

Sociodemographic Factors and Health Status

Among the 6,380 respondents, 67.7% (4,316 subjects) were females and 61.8% (3,943 subjects) were aged from 18 to 24 years. Most of the respondents (69.8%, 4.451 subjects) attended the Higher Education Institutions as undergraduate students,

90.3% of the study population had no history of underlying disease, 73.6% were non-smokers (4,693 individuals) and 50.2% of them did not regularly attend any annual check-ups by a physician. 73.6% of the participants had no restriction on performing PA. The sociodemographic characteristics of the participants and their health status are summarized in Table 1.

Table 1. Participants' Characteristics (socio-demographic Factors) in the Study, PA-Physical Activity

Studied variables	Number of participants (%)	Studied variables	Number of participants (%)
Age groups (years)		Daily	822 (48.73)
18-24	3,943 (61.80)	Occasionally (i.e., social smoker)	865 (51.27)
25-34	772 (12.10)	BMI level	
35-44	530 (8.31)	Normal	4,134 (64.80)
45-54	700 (10.97)	Underweight	322 (5.05%)
≥ 55	435 (6.82)	Overweight	1,466 (22.98)
Gender		Obese	458 (7.18)
Males	2,064 (32.35)	Difficulty maintaining weight	
Females	4,316 (67.65)	No	3,185 (50.28)
Housing- living with other people		Yes	3,149 (49.72)
No	2,128 (33.35)	History of underlying disease	
Yes	4,252 (66.65)	No	5,762 (90.31)
People living with		Yes	618 (9.69)
1 person	421 (9.90)	Disease (type)	
<5 people	3,783 (88.97)	Endocrine	190 (30.74)
≥5 people	48 (1.13)	Circulatory system	189 (30.58)
Permanent residency		Cancer	20 (3.24)
Hometown	3,950 (61.91)	Respiratory system	66 (10.68)
Other	2,430 (38.09)	Blood and the blood forming organs	28 (4.53)
Highest level of education		Digestive system	32 (5.18)
High school diploma	2,603 (40.80)	Other (i.e., musculoskeletal disease)	93 (15.05)
Bachelor's degree	760 (11.91)	Restrictions on performing PA	
MSc degree	875 (13.71)	No	455 (73.62)
PhD degree	2,142 (33.57)	Yes	163 (26.38)
Occupation		Preventive measures- Participants free of history of disease- annual check-up attendance	
Undergraduate student	4,451 (69.76)	No	2,088 (50.18)
Academician	707 (11.08)	Yes	2,073 (49.82)
Administrative officer	1,110 (17.39)	Participants with history of disease- advice from physician about PA	
Other (professor emeritus etc.)	112 (1.75)	No	195 (31.55)
Smoking status		Yes	423 (68.45)
Non-smokers	4,693 (73.56)	Regular follow-up attendance	
Never smoked	3,891 (82.91)	No	2,687 (46.63)
Smoked in the past	791 (16.85)	Yes	3,075 (53.37)
Duration of smoking cessation[*]	94.16±103.48[†]		
Alternatives (i.e., electronic cigarettes)	11 (0.23)		
Smokers	1,687 (26.44)		

[*]In months; [†]Median±IQR.

Physical Activity Conduction, and Intensity

A significant decrease (P<0.001) in both the conduct and intensity of PA was recorded between the pre-pandemic and the 2nd lockdown era. In particular, before the pandemic most respondents performed PA for a duration of more than an hour (92.4%) and were engaged in PA less than three times per week (61.3%), while during the 2nd lockdown, fewer respondents were engaged in PA (58.9%) and were performing PA irregularly (63.6%). Concerning the type of PA, walking was most frequently chosen in all periods (P<0.001), except during the second lockdown, when home

Table 2. Physical Activity (PA) Status of Survey Participants (N=6380). In Brackets, the Percentage of Each Reply per Question Category (the Percentage of Each Overall Reply to the Total Replies) and in Parentheses, the Distribution of Each Reply in Preview and New Cases (the Percentage of Previews and New to Overall Cases) Are Reported

Physical activity (PA) status			Examined period			
			Pre-pandemic era N (%)	First lockdown N (%)	Between lockdowns N (%)	Second lockdown N (%)
Engagement in PA	No	Previous cases*	-	121 (15.9)	450 (25.0)	1,463 (55.9)
		New cases†	-	640 (84.1)	1,350 (75.0)	1,156 (44.1)
		Overall‡	488 [7.6]	761 [11.9]	1,800 [28.2]	2,619 [41.1]
	Yes	Previous cases*	-	5,252 (93.5)	4,269 (93.2)	3,424 (91.0)
		New cases†	-	367 (6.5)	311 (6.8)	337 (9.0)
		Overall‡	5,892 [92.4]	5,619 [88.1]	4,580 [71.8]	3,761 [58.9]
	Total		6,380 [100.0]	6,380 [100.0]	6,380 [100.0]	6,380 [100.0]
PA Intensity	Irregular	Previous cases*	-	3,219 (89.8)	2,566 (92.6)	2,055 (85.9)
		New cases†	-	367 (10.2)	205 (7.4)	337 (14.1)
		Overall‡	3,614 [61.3]	3,586 [63.8]	2,771 [60.5]	2,392 [63.6]
	Regular	Previous cases*	-	2,033 (100.0)	1,703 (94.1)	1,369 (100.0)
		New cases†	-	-	106 (5.9)	-
		Overall‡	2,278 [38.7]	-	1,809 [39.5]	-
	Total		5,892 [100.0]	5,619 [100.0]	4,580 [100.0]	3,761 [100.0]
PA Type	Walking	Previous cases*	-	2,020 (90.9)	1,743 (100.0)	1,134 (93.0)
		New cases†	-	202 (9.1)		86 (7.0)
		Overall‡	1,956 [33.2]	2,222 [39.5]	1,743 [38.1]	1,220 [32.4]
	Running	Previous cases*	-	651 (96.7)	547 (100.0)	515 (90.7)
		New cases†	-	22 (3.3)		53 (9.3)
		Overall‡	454 [7.7]	673 [12.0]	547 [11.9]	568 [15.1]
	Sport	Previous cases*	-	94 (96.9)	82 (100.0)	54 (10.00)
		New cases†	-	3 (3.1)		
		Overall‡	724 [12.3]	97 [1.7]	82 [1.8]	54 [1.4]
	Gym	Previous cases*	-	-	-	-
		New cases†	-	-	-	-
		Overall‡	1,517 [25.7]	-	-	-
	Home workout	Previous cases*	-	2,077 (94.8)	1,564 (100.0)	1,237 (91.8)
		New cases†	-	115 (5.2)		110 (8.2)
		Overall‡	598 [10.1]	2,192 [39.0]	1,564 [34.1]	1,347 [35.8]
	Other	Previous cases*	-	410 (94.3)	333 (51.7)	484 (84.6)
		New cases†	-	25 (5.7)	311 (48.3)	88 (15.4)
		Overall‡	643 [10.9]	435 [7.7]	644 [14.1]	572 [15.2]
	Total		5,892 [100.0]	5,619 [100.0]	4,580 [100.0]	3,761 [100.0]

*As previous, all cases identified during the preceding period of the examined one (i.e., as per the conduction of PA the cases of the pre-pandemic era (121 cases) when the 1st lockdown is examined (overall cases: 761) are reported; New cases; †As new, all cases identified during the examined period [i.e., as per the PA conduction, the cases of the first lockdown (640 cases) when the 1st lockdown is examined (overall cases: 761)] are reported; ‡As overall, the total number of cases (sum of previous and new cases) are reported and indicated with brackets [ ]. Small brackets ( ) indicate the prevalence of each variable in previous status and new cases.

workout was preferred. The participants' PA levels during each period are summarized in Table 2.

Factors Associated with Conducting Physical Activity

Most of the respondents reported a loss of interest (52.4%) and various other factors, mainly the self-perceived improvement of their physical condition and overall health status (58.1%), as the primary factors related to the cessation or the continuation of the PA conduct, respectively. The perspective of surveyees on the relationship of the COVID-19 pandemic with the PA is depicted in Figure 3. The results of the univariable and multivariable logistic regression analyses (Table 3) indicate that

a) female gender, b) annual checkup attendance, and c) some types of PA during the pre-pandemic era are significantly associated with a decrease in the likelihood of stopping PA during lockdowns. Specifically, the likelihood of cessation of engagement in PA during the lockdowns decreased by 31.0% for female over male participants (OR, 0.69; 95% CI, 0.49-0.98; P=0.041), 47.0% for participants that attended checkups on an annual basis (OR, 0.53; 95% CI, 0.38-0.75; P<0.001) over the ones who did not, and 52.0% or 91.0% for participants choosing running (OR, 0.48; 95% CI, 0.23-0.98; P=0.044) or home workout (OR, 0.09; 95% CI, 0.02-0.36; P=0.001) over walking, as the preferred type of PA before the pandemic.
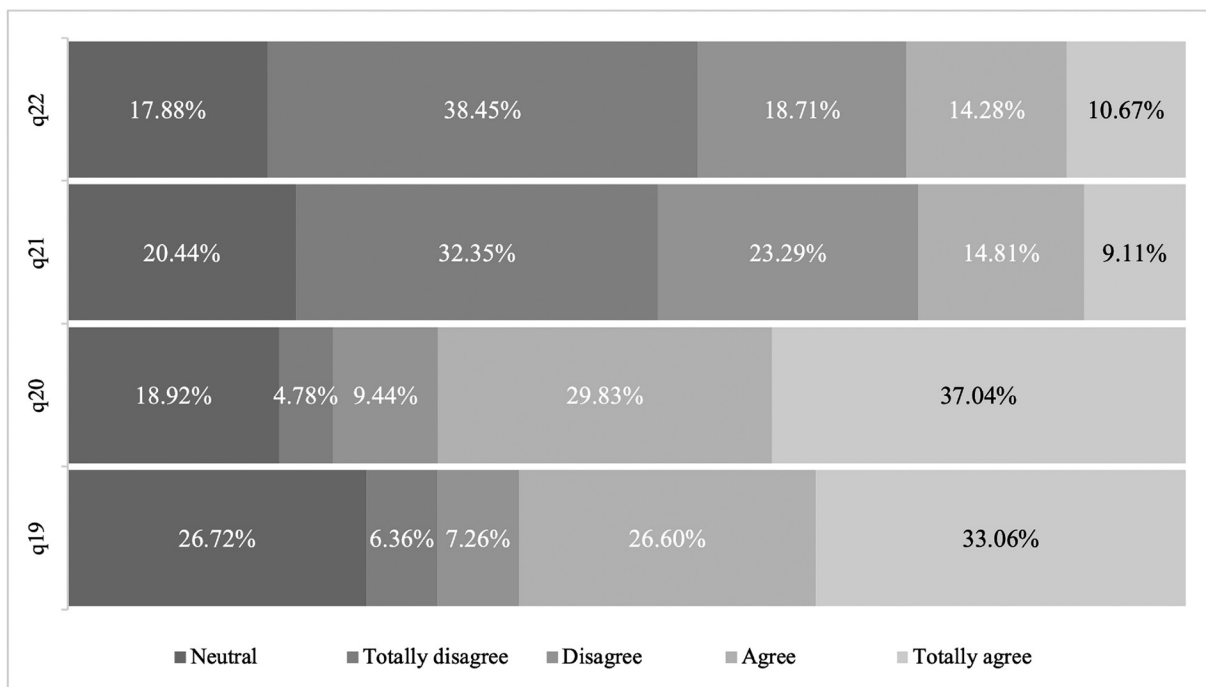

Figure 3. The perspective of surveyees regarding the relationship of the pandemic with physical activity according to their replies in the following questions (q19-q22), section 4 of the Likert scale.

q19 What is your position (on a scale of 1 to 5) on the phrase "After the end of the 2nd lockdown I am going to perform more physical activity"?

q20 What is your position (on a scale of 1 to 5) on the phrase "Today's lifestyle affects the ability to perform physical activity"?

q21 What is your position (on a scale of 1 to 5) on the phrase "The pandemic helped me to discover new forms of physical activity"?

q22 What is your position (on a scale of 1 to 5) on the phrase "The pandemic helped me to add physical activity into my daily routine"?

Table 3. The Output of the Univariable and Multivariable Logistic Regression Analyses regarding the Factors Associated with Physical Activity (PA) Cessation during the Lockdowns

Variables	Univariable models			Multivariable model		
	OR*	P-value†	95% CI	OR*	P-value†	95% CI
Age						
18-24 (ref.)	1.00	-	-	1.00	-	-
25-34	0.88	0.641	(0.53 -1.48)	0.92	0.781	(0.51 - 1.66)
35-44	1.47	0.123	(0.90 - 2.40)	1.36	0.398	(0.67 - 2.74)
45-54	1.6	0.024	(1.06 - 2.40)	1.67	0.168	(0.81 - 3.47)
≥ 55	1.01	0.998	(0.57 - 1.75)	1.08	0.858	(0.45 - 2.64)
Gender						
Male (ref.)	1.00	-	-	1.00	-	-
Female	0.76	0.070	(0.56 - 1.02)	0.69	0.041	(0.49 - 0.98)
BMI level						
Normal (ref.)	1.00	-	-	1.00	-	-
Underweight	1.13	0.747	(0.54-2.37)	1.47	0.322	(0.68-3.17)
Overweight	1.71	0.002	(1.22-2.39)	1.23	0.319	(0.82-1.84)
Obese	2.19	0.003	(1.31-3.67)	1.45	0.274	(0.75-2.83)
Housing (living with other people)						
No (ref.)	1.00	-	-	-	-	-
Yes	0.83	0.244	(0.61-1.13)	-	-	-
Number of people living with						
1 person (ref.)	1.00	-	-	-	-	-
< 5 people	0.82	0.494	(0.46-1.46)	-	-	-
≥ 5 people	0.74	0.778	(0.09-5.92)	-	-	-
Permanent residency						
No (ref.)	1.00	-	-	-	-	-
Yes	0.87	0.381	(0.64-1.18)	-	-	-
Highest level of education (degree)						
High school (ref.)	1.00	-	-	-	-	-
PhD	0.85	0.501	(0.54-1.35)	-	-	-
MSc	0.87	0.547	(0.55-1.38)	-	-	-
Bachelor	0.84	0.348	(0.59-1.21)	-	-	-
Occupation						
Undergraduate student (ref.)	1.00	-	-	1.00	-	-
Academician	1.13	0.582	(0.73-1.74)	0.68	0.312	(0.32 - 1.45)
Unemployed	1.47	0.416	(0.58-3.73)	1.41	0.501	(0.52 - 3.85)
White collar workers	1.36	0.099	(0.94-1.97)	0.96	0.897	(0.51 - 1.80)
Difficulty maintaining weight						
No (ref.)	1.00	-	-	1.00	-	-
Yes	1.72	0.002	(1.23 - 2.41)	1.47	0.065	(0.98 - 2.22)
Smoking						
No (ref.)	1.00	-	-	1.00	-	-
Yes	1.33	0.086	(0.96 - 1.85)	1.11	0.564	(0.77 - 1.61)
Smoking cessation (in months)	1.01	0.892	(0.96 - 1.05)	-	-	-
History of underlying diseases						
No (ref.)	1.00	-	-	-	-	-

Continuation of Table 3.

Variables	Univariable models			Multivariable model		
	OR*	P-value†	95% CI	OR*	P-value†	95% CI
Yes	1.22	0.41	(0.76 - 1.95)	-	-	-
Follow-up attendance						
No (ref.)	1.00	-	-	-	-	-
Yes	0.70	0.581	(0.20 - 2.50)	-	-	-
Restriction						
No (ref.)	1.00	-	-	-	-	-
Yes	1.49	0.428	(0.56 - 3.99)	-	-	-
Advice						
No (ref.)	1.00	-	-	-	-	-
Yes	0.99	0.982	(0.37 - 2.63)	-	-	-
Annual checkup attendance						
No (ref.)	1.00	-	-	1.00	-	-
Yes	0.54	<0.001	(0.39 - 0.74)	0.53	<0.001	(0.38 - 0.75)
Type of PA before the lockdown						
Walking (ref.)	1.00	-	-	1.00	-	-
Running	0.4	0.010	(0.20 - 0.80)	0.48	0.044	(0.23 - 0.98)
Sport	0.82	0.395	(0.52 - 1.30)	1.04	0.878	(0.63 - 1.73)
Gym	0.72	0.088	(0.49 - 1.05)	0.83	0.384	(0.54 - 1.27)
Home workout	0.07	<0.001	(0.02 - 0.28)	0.09	0.001	(0.02 - 0.36)
Other	0.81	0.392	(0.51 - 1.31)	0.98	0.936	(0.58 - 1.65)

*Odds ratio; †Stepwise multiple logistic regression analysis.

Discussion

The current study, performed in eight Higher Educational Institutions, evaluated the effect of COVID-related lockdowns at a national level. It recorded and identified the impact of the pandemic-related lockdowns on PA by examining two lockdowns, as well as the between-lockdown period. This fact allowed us to examine this impact from a broader perspective, given that PA was recorded in all possible periods with the between-lockdown period acting as an "atypical" follow-up to the first lockdown. Lockdowns, utilized worldwide during COVID- 19 pandemic, had numerous effects on public health, the economy, and industry (1). Lockdowns may be applied in the future in medical and/or other crises. This is why the current study remains important not only for its conclusion concerning the effects of this pandemic, but also for adopting preventive measures in future.

The present study demonstrated a significant reduction in PA levels due to COVID-related lockdowns. Furthermore, it showed that female gender, adherence to an annual checkup attendance, and some types of PA during the pre-pandemic era, were associated with a more active lifestyle. Reductions in PA levels were also highlighted in the majority of published studies (15-24), while others (25-28) concluded with contrasting results. This disparity could be attributed to the variability of the factors examined (e.g., the subjects' employment status) that further exhibit different outcomes in terms of PA-level maintenance. Additionally, the studies that concluded that there was an increase in PA during the pandemic enrolled mainly health professionals (25-28), while the current study's population was not necessarily limited to such individuals. In the meanwhile, socio-demographic factors, such as the place of permanent residency, that were found to significantly influence PA levels during

the COVID-19 pandemic in other studies (29-33), failed to be significantly associated in the current one. Concerning the association of PA with gender, most studies (34-38) found complementary results to those in the present study. The interpretation of this discrepancy may be attributed to the explanation provided by the study by van Uffelen et al. (39): women, as opposed to males, in their sixties, may perceive the lockdown as an opportunity to improve their external appearance, and this may act as a motivating factor for engagement in PA. Additionally, in relation to the association of the relationship between annual checkup attendance and the type of PA during the pre-pandemic era with the level of PA activity during the pandemic, to the best of our knowledge, no similar studies were identified, since several studies only highlight the increased engagement in home workout during and not prior to the lockdown.

No Engagement with Physical Activity and Effects

The current study concluded that there was quite a high percentage (41.1%) of no engagement with PA during the 2nd lockdown. As PA is beneficial for the population's general health, the long-term decrease in PA, and particularly no engagement at all, may lead to increased morbidity, obesity, high blood pressure, diabetes, musculoskeletal and psychological disorders, as well as a reduction in skeletal strength and endurance, and cardiorespiratory capacity (40, 41). Furthermore, the loss of lean mass, muscle function, and motor control may lead to sarcopenia, cardiometabolic disorders, and the emergence and/or worsening of other comorbidities, with significant impacts on the population and especially the elderly (42). These may affect the healthcare system, especially during long periods of lockdowns, such as COVID-related ones.

Measures for Maintaining Physical Activity at Beneficial Levels

Measures for maintaining PA in similar situations in the future may include: a) participation in online group training courses, which may be age and PA-level specific, and may be performed at local gyms by their members, b) proper public awareness of this issue, c) the ability to exercise in open areas (during possible lockdowns), and d) proper psychological support from professionals. It has been documented that PA supervision is recommended to improve the effects of exercise at home (42). This is possible through weekly visits, or telephone or online video calls. Health professionals, including physiotherapists, nutritionists, physical trainers, general and sports medicine physicians, psychologists, and health assistants should organize multidisciplinary programs aimed at promoting and maintaining PA, reducing functional losses during lockdowns, maintaining the general population's autonomy and life quality, in order to minimize morbidity and the burden on the healthcare systems.

Limitations of the Study

Although efforts to achieve a homogenous sample were made through the study design (inclusion of all individuals involved with each university regardless of their age), most of the respondents were students aged between 18-24 years of age residing in the two largest cities in Greece (Athens and Thessaloniki). This could potentially lead to a lower perception of other age groups and rural areas. Additionally, only subjective measures were used to record all the variables used, such as body weight, height, and PA conduct. Hence, PA may be overrepresented since subjective assessment was employed. Furthermore, the impact on PA engagement and its intensity, in all periods (the pre-pandemic, the first lockdown, the between-lockdowns, and the second lockdown) were recorded and compared, on the basis of the restrictive measures that were imposed in Greece during the pandemic. Hence, the potential difference in the restrictive measures between countries should be taken into consideration when interpreting the results.

Recall bias could have also influenced the study population's replies. To reduce the possibility of recall bias, all questions that were included were carefully selected to limit the effort of memory

needed to answer (for instance, the participants were asked to report the frequency of the PA months prior and after the time the responses were collected – during the lockdowns) and were asked for all individuals at the time that they joined the study. Yet, despite all efforts the possibility of the existence of recall bias should not be overlooked and should be taken into consideration when interpreting the results. Nevertheless, to the best of the authors' knowledge, this is the first study of this kind of the Greek population. Another limitation is the inclusion of respondents that were all related to universities, who were therefore undergoing a higher level of education, as well as the low response rate of participants (5.3%). Thus, the results might not apply to people with lower educational levels, or may be influenced by the fact that individuals that were not conducting PA refused to participate (non-response bias).

Conclusions

PA conduct and intensity were significantly reduced from the pre-pandemic era to the second lockdown. Female gender, annual checkup attendance, and the type of PA during the pre-pandemic era were significantly associated with a decrease in the likelihood of stopping PA during lockdowns. PA may be beneficial for the population's health. Therefore, measures such as online group training sessions and public awareness, should be implemented in cases of future lockdowns to avoid PA reduction during such periods.

What Is Already Known on This Topic:
Physical activity (PA) is beneficial for the population's general health. Long-term decreases in PA may lead to increased morbidity, including obesity, high blood pressure, diabetes, musculoskeletal and psychological disorders, as well as a reduction in skeletal strength, and endurance and cardiorespiratory capacity. The loss of lean mass, muscle function, and motor control may lead to sarcopenia, cardiometabolic disorders, and the emergence and/or worsening of other comorbidities, with significant impacts on the population and especially the elderly. These may affect the healthcare system, especially during long periods of lockdowns, such as COVID-related ones.

What This Study Adds:
The current survey showed that physical activity (PA) conduct and intensity were reduced from the pre-pandemic era to the second lockdown

to a statistically significant degree. Female gender, annual checkup attendance, and the type of PA during the pre-pandemic era are significantly associated with a decrease in the likelihood of stopping PA during lockdowns. PA may be beneficial for the population's general health. Therefore, measures, such as online group training sessions and public awareness, should be implemented in cases of future lockdowns to avoid reductions in PA during such periods. Health professionals, including physiotherapists, nutritionists, physical trainers, general and sports medicine physicians, psychologists, and health assistants, should organize multidisciplinary programs aimed at promoting and maintaining PA, reducing functional losses during lockdowns, maintaining the general population's autonomy and quality of life, and to minimize morbidity and the burden on the health-care system.

References

1. Cucinotta D, Vanelli M. WHO Declares COVID-19 a Pandemic. Acta Biomed. 2020;91(1):157-60. doi: 10.23750/abm.v91i1.9397.

2. Kousi T, Mitsi LC, Simos J. The Early Stage of COVID-19 Outbreak in Greece: A Review of the National Response and the Socioeconomic Impact. Int J Environ Res Public Health. 2021;18(1):322. doi 10.3390/ijerph18010322.

3. Porrovecchio A, Olivares PR, Masson P, Pezé T, Lombi L. The Effect of Social Isolation on Physical Activity during the COVID-19 Pandemic in France. Int J Environ Res Public Health. 2021;18(10):5070. doi: 10.3390/ijerph18105070.

4. Sallis JF, Adlakha D, Oyeyemi A, Salvo D. An international physical activity and public health research agenda to inform coronavirus disease-2019 policies and prac-

tices. J Sport Health Sci. 2020;9(4):328-34. doi: 10.1016/j.jshs.2020.05.005. Epub 2020 May 22.

5. Duncan GE, Sydeman SJ, Perri MG, Limacher MC, Martin AD. Can sedentary adults accurately recall the intensity of their physical activity? Prev Med. 2001;33(1):18-26. doi: 10.1006/pmed.2001.0847.

6. Gaetano A. Relationship between physical inactivity and effects on individual health status. Journal of Physical Education and Sport. 2016;16(2):1069-74. doi:10.7752/jpes.2016.s2170.

7. González K, Fuentes J, Márquez JL. Physical Inactivity, Sedentary Behavior and Chronic Diseases. Korean J Fam Med. 2017;38(3):111-5. doi: 10.4082/kjfm.2017.38.3.111. Epub 2017 May 23.

8. Pratt M, Ramirez Varela A, Salvo D, Kohl Iii HW, Ding D. Attacking the pandemic of physical inactivity: what is holding us back? Br J Sports Med. 2020;54(13):760-2. doi: 10.1136/bjsports-2019-101392. Epub 2019 Nov 8.

9. Kohl HW 3rd, Craig CL, Lambert EV, Inoue S, Alkandari JR, Leetongin G, et al. The pandemic of physical inactivity: global action for public health. Lancet. 2012;380(9838):294-305. doi: 10.1016/S0140-6736(12)60898-8.

10. Del Pozo Cruz B, Ahmadi MN, Lee IM, Stamatakis E. Prospective Associations of Daily Step Counts and Intensity With Cancer and Cardiovascular Disease Incidence and Mortality and All-Cause Mortality. JAMA Intern Med. 2022;182(11):1139-48. doi: 10.1001/jamainternmed.2022.4000.

11. Saint-Maurice PF, Troiano RP, Bassett DR Jr, Graubard BI, Carlson SA, Shiroma EJ, et al. Association of Daily Step Count and Step Intensity With Mortality Among US Adults. JAMA. 2020;323(12):1151-60. doi: 10.1001/jama.2020.1382.

12. De Moor MH, Beem AL, Stubbe JH, Boomsma DI, De Geus EJ. Regular exercise, anxiety, depression and personality: a population-based study. Prev Med. 2006;42(4):273-9. doi: 10.1016/j.ypmed.2005.12.002. Epub 2006 Jan 24.

13. Mandolesi L, Polverino A, Montuori S, Foti F, Ferraioli G, Sorrentino P, et al. Effects of Physical Exercise on Cognitive Functioning and Wellbeing: Biological and Psychological Benefits. Front Psychol. 2018;9:509. doi: 10.3389/fpsyg.2018.00509.

14. Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. Br J Sports Med. 2020;54(24):1451-62. doi: 10.1136/bjsports-2020-102955.

15. Buoite Stella A, AjČeviĆ M, Furlanis G, Cillotto T, Menichelli A, Accardo A, et al. Smart technology for physical activity and health assessment during COVID-19 lockdown. J Sports Med Phys Fitness. 2021;61(3):452-60. doi: 10.23736/S0022-4707.20.11373-2. Epub 2020 Oct 22.

16. Folk AL, Wagner BE, Hahn SL, Larson N, Barr-Anderson DJ, Neumark-Sztainer D. Changes to Physical Activity during a Global Pandemic: A Mixed Methods Analysis among a Diverse Population-Based Sample of Emerging Adults in the U.S. Int J Environ Res Public Health. 2021;18(7):3674. doi: 10.3390/ijerph18073674.

17. He M, Xian Y, Lv X, He J, Ren Y. Changes in Body Weight, Physical Activity, and Lifestyle During the Semi-lockdown Period After the Outbreak of COVID-19 in China: An Online Survey. Disaster Med Public Health Prep. 2021;15(2):e23-8. doi: 10.1017/dmp.2020.237. Epub 2020 Jul 14.

18. Koohsari MJ, Nakaya T, McCormack GR, Shibata A, Ishii K, Oka K. Changes in Workers' Sedentary and Physical Activity Behaviors in Response to the COVID-19 Pandemic and Their Relationships With Fatigue: Longitudinal Online Study. JMIR Public Health Surveill. 2021;7(3):e26293. doi: 10.2196/26293.

19. Martínez-de-Quel Ó, Suárez-Iglesias D, López-Flores M, Pérez CA. Physical activity, dietary habits and sleep quality before and during COVID-19 lockdown: A longitudinal study. Appetite. 2021;158:105019. doi: 10.1016/j.appet.2020.105019. Epub 2020 Nov 5.

20. Ong JL, Lau T, Massar SAA, Chong ZT, Ng BKL, Koek D, et al. COVID-19-related mobility reduction: heterogenous effects on sleep and physical activity rhythms. Sleep. 2021;44(2):zsaa179. doi: 10.1093/sleep/zsaa179.

21. Park JH, Yoo E, Kim Y, Lee JM. What Happened Pre- and during COVID-19 in South Korea? Comparing Physical Activity, Sleep Time, and Body Weight Status. Int J Environ Res Public Health. 2021;18(11):5863. doi: 10.3390/ijerph18115863.

22. Wilson OWA, Holland KE, Elliott LD, Duffey M, Bopp M. The Impact of the COVID-19 Pandemic on US College Students' Physical Activity and Mental Health. J Phys Act Health. 2021;18(3):272-8. doi: 10.1123/jpah.2020-0325. Epub 2021 Feb 18.

23. Zheng C, Huang WY, Sheridan S, Sit CH, Chen XK, Wong SH. COVID-19 Pandemic Brings a Sedentary Lifestyle in Young Adults: A Cross-Sectional and Longitudinal Study. Int J Environ Res Public Health. 2020;17(17):6035. doi: 10.3390/ijerph17176035.

24. Cheval B, Sivaramakrishnan H, Maltagliati S, Fessler L, Forestier C, Sarrazin P, et al. Relationships between changes in self-reported physical activity, sedentary behaviour and health during the coronavirus (COVID-19) pandemic in France and Switzerland. J Sports Sci. 2021;39(6):699-704. doi: 10.1080/02640414.2020.1841396. Epub 2020 Oct 29.

25. Franco E, Urosa J, Barakat R, Refoyo I. Physical Activity and Adherence to the Mediterranean Diet among Spanish Employees in a Health-Promotion Program before and during the COVID-19 Pandemic: The Sanitas-Healthy Cities Challenge. Int J Environ Res Public Health. 2021;18(5):2735. doi: 10.3390/ijerph18052735.

26. Gallego-Gómez JI, Campillo-Cano M, Carrión-Martínez A, Balanza S, Rodríguez-González-Moro MT, Simonelli-Muñoz AJ, et al. The COVID-19 Pandemic and Its Impact on Homebound Nursing Students. Int J Environ Res Public Health. 2020;17(20):7383. doi: 10.3390/ijerph17207383.

27. Romero-Blanco C, Rodríguez-Almagro J, Onieva-Zafra MD, Parra-Fernández ML, Prado-Laguna MDC, Hernández-Martínez A. Physical Activity and Sedentary Lifestyle in University Students: Changes during Confinement Due to the COVID-19 Pandemic. Int J Environ Res Public Health. 2020;17(18):6567. doi: 10.3390/ijerph17186567.

28. Beck AM, Gilbert AS, Duncan DD, Wiedenman EM. A Cross-Sectional Comparison of Physical Activity during COVID-19 in a Sample of Rural and Non-Rural Participants in the US. Int J Environ Res Public Health. 2021;18(9):4991. doi: 10.3390/ijerph18094991.

29. Forbes CC, Yu ZM, Cui Y, DeClercq V, Grandy SA, Parker L, et al. Rural-Urban Disparities in Total Physical Activity, Body Composition, and Related Health Indicators: An Atlantic PATH Study. J Rural Health. 2020;36(1):111-9. doi: 10.1111/jrh.12363. Epub 2019 Mar 13.

30. McCrorie P, Mitchell R, Macdonald L, Jones A, Coombes E, Schipperijn J, et al. The relationship between living in urban and rural areas of Scotland and children's physical activity and sedentary levels: a country-wide cross-sectional analysis. BMC Public Health. 2020;20(1):304. doi: 10.1186/s12889-020-8311-y.

31. McGrath A, Murphy N, Richardson N. The impact of the COVID-19 pandemic on the wellbeing of Irish Men's Shed members. Health Promot Int. 2021;36(4):1007-19. doi: 10.1093/heapro/daaa113.

32. Rice WL, Mateer TJ, Reigner N, Newman P, Lawhon B, Taff BD. Changes in recreational behaviors of outdoor enthusiasts during the COVID-19 pandemic: analysis across urban and rural communities. Journal of Urban Ecology. 2020;6(1):juaa020. doi: 10.1093/jue/juaa020. Epub 2020 Aug 14.

33. Baceviciene M, Jankauskiene R. Changes in sociocultural attitudes towards appearance, body image, eating attitudes and behaviours, physical activity, and quality of life in students before and during COVID-19 lockdown. Appetite. 2021;166:105452. doi: 10.1016/j.appet.2021.105452. Epub 2021 Jun 6.

34. Elnaggar RK, Alqahtani BA, Mahmoud WS, Elfakharany MS. Physical Activity in Adolescents During the Social Distancing Policies of the COVID-19 Pandemic. Asia Pac J Public Health. 2020;32(8):491-4. doi: 10.1177/1010539520963564.

35. Hino K, Asami Y. Change in walking steps and association with built environments during the COVID-19 state of emergency: A longitudinal comparison with the first half of 2019 in Yokohama, Japan. Health Place. 2021;69:102544. doi: 10.1016/j.healthplace.2021.102544. Epub 2021 Mar 10.

36. Sekulic D, Blazevic M, Gilic B, Kvesic I, Zenic N. Prospective Analysis of Levels and Correlates of Physical Activity during COVID-19 Pandemic and Imposed Rules of Social Distancing; Gender Specific Study among Adolescents from Southern Croatia. Sustainability. 2020;12(10):4072. doi: https://doi.org/10.3390/su12104072.

37. To QG, Duncan MJ, Van Itallie A, Vandelanotte C. Impact of COVID-19 on Physical Activity Among 10,000 Steps Members and Engagement With the Program in Australia: Prospective Study. J Med Internet Res. 2021;23(1):e23946. doi: 10.2196/23946.

38. Wang Y, Zhang Y, Bennell K, White DK, Wei J, Wu Z, et al. Physical Distancing Measures and Walking Activity in Middle-aged and Older Residents in Changsha, China, During the COVID-19 Epidemic Period: Longitudinal Observational Study. J Med Internet Res. 2020;22(10):e21632. doi: 10.2196/21632.

39. van Uffelen JGZ, Khan A, Burton NW. Gender differences in physical activity motivators and context preferences: a population-based study in people in their sixties. BMC Public Health. 2017;17(1):624. doi: 10.1186/s12889-017-4540-0.

40. Lin YA, Chen YJ, Tsao YC, Yeh WC, Li WC, Tzeng IS, Chen JY. Relationship between obesity indices and hypertension among middle-aged and elderly populations in Taiwan: a community-based, cross-sectional study. BMJ Open. 2019;9(10): e031660. doi: 10.1136/bmjopen-2019-031660

41. Powell-Wiley TM, Poirier P, Burke LE, Després JP, Gordon-Larsen P, Lavie CJ, et al. Obesity and Cardiovascular Disease: A Scientific Statement From the American Heart Association. Circulation. 2021;143(21): e984-e1010. doi:10.1161/CIR.0000000000000973.

42. Oliveira MR, Sudati IP, Konzen VM, de Campos AC, Wibelinger LM, Correa C, et al. Covid-19 and the impact on the physical activity level of elderly people: A systematic review. Exp Gerontol. 2022;159:111675. doi: 10.1016/j.exger.2021.111675.

Appendix

Questionnaire

Section 1 – Sociodemographic factors						
q1	What is your age?*					
q2	What is your gender?*					
	☐	Male	☐	Female	☐	Other
q3	Do you live with other people permanently?*					
	☐	Yes	☐	No	☐	Don't want to declare
q3.1	With how many people do you live? *					
	☐	1 person	☐	Up to 5 people	☐	More than 5 people
q4	Do you live permanently in your hometown? *					
	☐	Yes	-	-	☐	No
q5	In which of the following Greek Administrative regions do you live permanently? *					
	☐	Attica	☐	Epirus	☐	Thessaly
	☐	Central Greece	☐	Ionian Islands	☐	Western Greece
	☐	Central Macedonia	☐	North Aegean	☐	Western Macedonia
	☐	Crete	☐	Peloponnese	☐	Other
	☐	Eastern Macedonia and Thrace	☐	South Aegean	-	-
q6	What is your educational level? (Choose based on the last level you are at now, or graduated from) *					
	☐	High school diploma	-	-	☐	Bachelor's degree
	☐	Master's degree	-	-	☐	PhD
	☐	Other	-	-	-	-
q7	What is your current occupation?*					
	☐	Undergraduate student		-	☐	Academician
	☐	Administrative officer		-	☐	Other
q8	Do you smoke?*					
	☐	Yes	☐	No	☐	Don't want to declare	☐	Other
q8.1	How long is it since you quit smoking (in months)?*					
Section 2 – Health status						
q9	What is your body weight (in kg without decimal approximation)?*					
q10	What is your height (in cm without decimal approximation)?*					
q11	Do you find it difficult to maintain your weight?*					
	☐	Yes	☐	No	☐	Don't want to declare
q12	Do you have a diagnosed underlying disease?*					
	☐	Yes	☐	No	☐	Don't want to declare
q12.1	What is that disease you have been diagnosed with?*					
q12.2	Do you attend a regular (at least annual) follow-up by a physician for this underlying disease?*					
	☐	Yes	-	-	☐	No
q12.3	Does this underlying disease affect (restrict) your ability to perform physical activity?*					
	☐	Yes	-	-	☐	No
q12.4	Have you received any advice from your physician about the conduct of physical activity (i.e., instructions on when and how to perform physical activity)?*					
	☐	Yes	-	-	☐	No
Section 3 – Physical activity status						

q13	Before the COVID - 19 pandemic, how many days within a week did you perform physical activity lasting at least 30 minutes each time?*					
	☐	1 day/week	☐	2 days/week	☐	3 days/week
	☐	4 days/week	☐	5 days/week	☐	6 days/week
	☐	Everyday	-	-	-	-
q14	Before the COVID-19 pandemic, what physical activity did you perform with an average duration of more than 30 minutes? (In case many options may be chosen, please choose the most frequent one)*					
q15	During the 1st lockdown, what physical activity did you perform with an average duration of more than 30 minutes? (In case many options may be chosen, please choose the most frequent one)*					
q15.1	Which factor do you consider as having a positive effect on the performance of physical activity?*					
q17	After the end of the 1st lockdown, did you continue to perform physical activity?*					
	☐	Yes			☐	No
q17.1	Did you continue to perform physical activity with the same or a different frequency?*					
	☐	Same			☐	Different
q17.2	Why did you stop?*					
q17.3	Which reason helped you to continue your physical activity?*					
q18	During the 2nd lockdown, did you perform physical activity?*					
	☐	Yes			☐	No
q18.1	During the 2nd lockdown, did you continue to perform the same physical activity as before?*					
	☐	Same			☐	Other
q18.2	What is the new physical activity you started?*					
Section 4 – Perspective regarding the relationship of the pandemic with physical activity						
q19	What is your position (on a scale of 1 to 5) on the phrase "After the end of the 2nd lockdown I am going to perform more physical activity"?*					
	(Disagree)	1	2	3	4	5	(Agree)
q20	What is your position (on a scale of 1 to 5) on the phrase "Today's lifestyle affects the ability to perform physical activity"?*					
	(Disagree)	1	2	3	4	5	(Agree)
q21	What is your position (on a scale of 1 to 5) on the phrase „The pandemic helped me to discover new forms of physical activity"?*					
	(Disagree)	1	2	3	4	5	(Agree)
q22	What is your position (on a scale of 1 to 5) on the phrase "The pandemic helped me to add physical activity into my daily routine"?*					
	(Disagree)	1	2	3	4	5	(Agree)

*Manda tory field.