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Original Investigation

Post-Acute Sequelae of COVID-19 in Adolescents: A Cross-Sectional Study on Perceived Physical Activity Decline and Mental Health

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Purpose: The COVID-19 pandemic has severely impacted the mental and physical well-being of adolescents. In particular, the literature has shown that the pandemic has had a significant impact on anxiety, depression and physical activity. The present study aims to investigate whether adolescents have changed their frequency of physical activity after the pandemic. It also examines whether these changes were in any way related to their mental health status in the post-acute phase of the COVID-19 pandemic, when the immediate emergency measures had subsided, but residual psychological consequences were still observable.
Methods: A sample of 218 high school students (Female=130; Male= 88) from two Italian public schools completed the Depression Anxiety Stress Scale (DASS-21) and the International Physical Activity Questionnaire (IPAQ), along with ad hoc questions to assess their self-perceived impact of COVID-19 on their physical activity. Multinomial logistic regression analysis was used to examine the relationships between mental health variables and physical activity behavior.
Results: Stress, anxiety and depression were significant predictors of a perceived reduction in physical activity, with depression showing the strongest influence ($\chi^2(6) = 31.489$, $P< .001$; $\chi^2(6) = 32.223$, $P< .001$; $\chi^2(6) = 40.083$, $P< .001$). In addition, gender differences were notable: women reported higher levels of psychological distress and a greater decrease in physical activity. The IPAQ data confirmed that most respondents experienced a decrease in physical activity after the pandemic and linked this to the psychological experiences of the pandemic.
Conclusions: To our knowledge, this is the first study to show how COVID-19 affects the frequency of physical activity in adolescents and how this change is related to the psychological distress they reported as a result of the pandemic. These findings highlight the need for school and community-based interventions that combine physical activity promotion with mental health support, particularly for vulnerable subgroups such as female adolescents.

Keywords: DASS-21; COVID-19 pandemic; Psychological distress; Anxiety; Depression; Self-perception

Introduction

The COVID-19 pandemic has had an unprecedented impact on global health[1-3], with psychological and behavioral consequences that persist into the post-acute phase of the pandemic[4]. Adolescence is characterized by increased vulnerability to mental health disorders, including anxiety and depression, often exacerbated by environmental stressors[5]. As adolescents go through important stages of their development, their psychological well-being is closely linked to physical activity (PA), social interactions and maintaining regular routine[5,6]. One of the means of mitigating these symptoms is PA, which can improve adolescents' mental health. Studies have shown that adolescents who engage in regular PA have lower levels of anxiety, depression and stress[7,8]. However, during the recent pandemic[4,9], levels of PA – which have been shown to counteract psychological distress[10] – declined due to school closures and reduced opportunities for structured exercise, exacerbating the psychological effects[11-13]. The disruption of these protective factors, particularly through lockdowns, school closures, social distancing and the inability to engage in group PA, has led to widespread mental health challenges, with anxiety and depression rates soaring among adolescents[14]. A systematic review has shown that symptoms of depression and anxiety have doubled in children and adolescents during the pandemic[15]. Gender-specific differences have also been repeatedly identified. Females are generally more prone to internalizing mental disorders such as anxiety and depression[16] and reported higher levels of psychological distress than males during the pandemic[17]. Although previous studies have shown that perceptions of reduced PA are closely related to self-reported mental health problems such as anxiety and depression[12], few have examined the persistence of these effects over the long term.

In particular, the interaction between adolescents' subjective perception of PA reduction and their current mental health problems remains poorly understood, even several years after the onset of the disease. The aim of this study was to investigate the long-term perception of PA changes due to the pandemic and their association with current mental health indicators such as anxiety, stress and depression. For the purposes of this study, the term "long-term effects" refers to persistent psychological and behavioral effects observed more than three years after the initial global outbreak (March 2020), in line with recent frameworks on the lasting mental health consequences of the pandemic[18]. The present study aimed to examine whether such patterns were evident in the adolescent population using ad hoc questions that prompted reflection on the pandemic period. In addition, the study investigated the extent to which these subjective perceptions correspond to objectively measured declines in PA.

Methods

Participants

Two hundred and eighteen students (F=130; M=88) with a mean age of 18.4±.50 years (18 to 20 years old) were enrolled in their final year of high school in 2023. Participants were recruited through a convenience sample in collaboration with two public high schools. All students in the last school year at the two schools were invited to participate voluntarily in the study during regular school hours. As this was a convenience sample, the inclusion criteria for participation in the study were not determined a priori, but based on the following criteria: i) final year of high school; ii) informed consent; iii) complete response to the survey. Exclusion criteria included incomplete responses, or lack of consent. After applying these criteria, a total of 205 responses were selected for analysis. Anthropometric data were self-reported by 205 participants. Thirteen participants did not adequately respond to the questionnaires and were therefore excluded from the analysis.

The average weight was 61.06±9.70 kg, an average height of 1.71±.09 m, an average BMI (Body Mass Index is calculated in kg/m²)[19] of 20.79 ±2.15. The research was conducted in compliance with the European General Data Protection Regulation (GDPR 2016/679), ensuring the anonymity and confidentiality of all participant data. All participants gave informed consent in accordance with the Declaration of Helsinki. The study protocol was approved by the [Ethics Committee of the Faculty of Kinesiology, University of Split, Split, Croatia (approval number: 2181-205-02-05- 24- 0021).]

Experimental Design

The data was collected anonymously via an online survey platform (Google Forms), which integrated all questionnaires into a single task. Participants were asked to read the questions carefully and to answer the questionnaire honestly and accurately.

Depression Anxiety Stress Scale (DASS-21)

The Italian short version of the questionnaire shows good consistency in measuring general distress and the three specific dimensions (i.e. depression, anxiety and stress). The test was also suitable for adolescents from different cultures[20] to measure symptoms of depression, anxiety and stress with seven items per subscale. All items were rated on a 4-point Likert scale (0 = Does not apply to me at all; 1 = Applies to me to some extent or sometimes; 2 = Applies to me to a considerable extent or a good part of the time; 3 = Applies to me very much or most of the time). To assess the severity of depression, anxiety and stress symptoms, the items of the individual subscales were summed and doubled to correspond to the original DASS-42[21]. The DASS-21 severity levels are classified per *Depression*: normal (0–9), mild (10–13), moderate (14–20), severe (21–27), extremely severe (≥28); *Anxiety*: normal (0–7), mild (8–9), moderate (10–14), severe (15–19), extremely severe (≥20); *Stress*: normal (0–14), mild (15–18), moderate (19–25), severe (26–33), extremely severe (≥34).

International Physical Activity Questionnaire (IPAQ) – 7 items

To monitor their PA level, participants were asked to complete the 7-item IPAQ. This self-report instrument is widely used for surveillance of PA in populations aged 15 to 69 years[22,23]. The questionnaire investigates the frequency and duration of PA performed for at least 10 consecutive minutes over the past seven days across three intensity domains: vigorous, moderate, and walking. The final item measures time spent sitting on a typical weekday. Total weekly energy expenditure is calculated in MET-minutes as follows:

*WalkingMET-minutes/week=3.3*walking minutes*walking days*
*Moderate MET-minutes/week = 4.0 * moderate-intensity activity minutes * moderate days*
*Vigorous MET-minutes/week = 8.0 * vigorous-intensity activity minutes * vigorous-intensity days*
Total physical activity MET-minutes/week = sum of Walking + Moderate + Vigorous METS-minutes/week scores.

Regarding the categorization of the sample, certain threshold values must therefore be reached in order to be classified as a high-, medium- or low-active person. More specifically, the classification followed the official IPAQ assessment protocol. Participants were divided into the following categories: i) Highly active: ≥3 days of vigorous activity totalling at least 1500 MET-min/week or ≥7 days of combined activity totalling at least 3000 MET-min/week; ii) Moderately active: ≥3 days of vigorous activity (≥20 minutes/day) or ≥5 days of moderate activity or walking (≥30 minutes/day) or ≥5 days of any combination of activities reaching ≥600 MET-min/week; iii) Low active: individuals not meeting the criteria for moderate or high activity. In this study, the 187-person sample yielded 97 "highly active" individuals, 67 "moderately active" and 23 "low active" individuals.

Self-perceived impact of COVID-19

Finally, the last section of the form reported generic questions regarding self-perceived impact of COVID-19 on their will and the kind of practiced PA. The three questions were developed by an interdisciplinary team of psychologists and sport science researchers with the purpose of exploring adolescents' subjective perceptions of change in PA and motivation after the COVID-19 pandemic. A small pilot test (n=15) was conducted among students from a similar age group to evaluate clarity, with minor wording adjustments made accordingly. The items were ultimately used to complement standardized self-report tools (DASS-21 and IPAQ) and provide context-specific, perception-based data:

1) Did you use to practice physical or sport activities continuously before COVID-19 pandemic?
   "Yes, the same activity as today"; "Yes, but another activity compared to the current one I do now"; "Yes, but now I don't practice any activity anymore"; "No, I didn't practice any activity".
2) Compared to your today's sport/physical activity, you consider that before COVID-19 it was*: "The same frequency and intensity"; "Very higher in frequency and intensity"; "Very lower in frequency and intensity"*.

3) Thinking on sport/physical activities before COVID-19, you believe that the pandemic has*: "No influence on my will to take part of a physical activity now"; "Positively influenced my will to take part of a physical activity now"; "Negatively influenced my will to take part of a physical activity now"*. The answers have been coded as follows: 1-2-3-4 for the first question, 1-2-3 for the second question and 1-2-3 for the third question.

Statistical analysis

Descriptive statistics were performed on respondents' self-perceived impact of COVID-19 on their willpower and type of PA performed (Table 1). A multinomial logistic regression analysis was performed for each item of the self-perceived COVID-19 impact questionnaire, using gender and the three subscales of the DASS-21 (anxiety, depression, and stress) as predictor variables. The same regression model was subsequently applied, replacing the DASS-21 subscales with the IPAQ classification (i.e., High/Moderate/Low level of PA). The first response level (1) of the self-perceived impact scale of COVID-19 was set as the reference category. For each analysis, model assumptions were verified. The likelihood ratio test was used to assess the significance of the predictor variables, while Pearson's chi-square and deviance tests were applied to evaluate model fit. Nagelkerke's pseudo R-squared was also calculated. The alpha level was set at .05, where the $P< .05$ was considered significant, and data analysis was performed using IBM SPSS Statistics version 29.0.1.0 (Chicago, IL, USA).

Results

Self-perceived impact of COVID-19 questionnaire

- *Subgroup anxiety*

For the question 1 of the self-perceived impact of COVID-19 questionnaire the model was statistically significant ($\chi^2_{(6)}$ = 32.223, $P< .001$), Pseudo R^2= .148, Pearson and Deviance test indicated a good fit ($\chi^2_{(15)}$ = 15.649, P= .406; $\chi^2_{(15)}$ = 15.540, P= .413) and likelihood ratio tests showed a significant contribution of both predictors (sex: $\chi^2_{(3)}$ = 10.052, P= .018; anxiety: $\chi^2_{(3)}$ = 10.027, P= .018). For the question 2 the model was statistically significant ($\chi^2_{(4)}$ = 19.415, $P<$ .001), Pseudo R^2= .097, Pearson and Deviance test indicated a good fit ($\chi^2_{(10)}$ = 11.071, P= .352; $\chi^2_{(10)}$ = 10.812, P= .372) and likelihood ratio tests showed a significant contribution of one predictor (sex: $\chi^2_{(2)}$ = 4.987, P= .083; anxiety: $\chi^2_{(2)}$ = 10.411, P= .005). For the question 3 the model was statistically significant ($\chi^2_{(4)}$ = 10.844, P= .028), Pseudo R^2= .055, Pearson and Deviance test did not indicate a good fit ($\chi^2_{(10)}$ = 19.775, P=. 031; $\chi^2_{(10)}$ = 23.394, P= .009) and likelihood ratio tests showed a significant contribution of one predictor (sex: $\chi^2_{(2)}$ = 6.213, P=.045; anxiety: $\chi^2_{(2)}$ =.960, P= .619). In Table 2 the coefficients of predictors sex and anxiety are shown for all levels compared to level 1.

- *Subgroup depression*

For the Item 1 of the self-perceived impact of COVID-19 questionnaire the model was statistically significant ($\chi^2_{(6)}$ = 40.083, $P< .001$), Pseudo R^2= .181, Pearson and Deviance test indicated a good fit ($\chi^2_{(15)}$ = 18.207, P= .252; $\chi^2_{(15)}$ = 15.789, P= .396) and likelihood ratio tests showed a significant contribution of both predictors (sex: $\chi^2_{(3)}$ = 15.924, P= .001; depression: $\chi^2_{(3)}$ = 17.888, $P< .001$). For the Item 2 the model was statistically significant ($\chi^2_{(4)}$ = 20.731, $P<$ .001), Pseudo R^2= .103, Pearson and Deviance test indicated a good fit ($\chi^2_{(10)}$ = 7.516, P= .676; $\chi^2_{(10)}$ = 7.947, P= .634) and likelihood ratio tests showed a significant contribution of both predictors (sex: $\chi^2_{(2)}$ = 7.559, P=.023; depression: $\chi^2_{(2)}$ = 11.727, P=.003). For the Item 3 the model was statistically significant ($\chi^2_{(4)}$ = 10.367, P= .035), Pseudo R^2= .052, Pearson and Deviance test indicated a good fit ($\chi^2_{(10)}$ = 14.124, P= .167; $\chi^2_{(10)}$ = 15.979, P= .100) and likelihood ratio tests showed a significant contribution of one predictor (sex: $\chi^2_{(2)}$ = 8.966, P=.011; depression: $\chi^2_{(2)}$ = .483, P= .786). In Table 2 the coefficients of predictors sex and anxiety are shown for all levels compared to level 1.

- *Subgroup stress*

For the Item 1 of the self-perceived impact of COVID-19 questionnaire the model was statistically significant ($\chi^2_{(6)}$ = 31.489, $P< .001$), Pseudo R^2= .145, Pearson and Deviance test indicated a good fit ($\chi^2_{(9)}$ = 6.952, P= .642; $\chi^2_{(9)}$ = 7.447, P= .591) and likelihood ratio tests showed a significant contribution of both predictors (sex: $\chi^2_{(3)}$ = 15.420, P= .001; stress: $\chi^2_{(3)}$ = 9.293, P= .026). For the Item 2 the model was statistically significant ($\chi^2_{(4)}$ = 17.228, P= .002), Pseudo R^2= .086, Pearson and Deviance test indicated a good fit ($\chi^2_{(6)}$ = 6.551, P= .364; $\chi^2_{(6)}$ = 7.018, P= .319) and likelihood ratio tests showed a significant contribution of both predictors (sex: $\chi^2_{(2)}$ = 6.216, P= .045; stress: $\chi^2_{(2)}$ = 8.224, P= .016). For the Item 3 the model was statistically significant ($\chi^2_{(4)}$ = 9.985, P= .041), Pseudo R^2= .051, Pearson and Deviance test indicated a good fit ($\chi^2_{(6)}$ = 5.027, P= .540; $\chi^2_{(6)}$ = 5.284, P= .508) and likelihood ratio tests showed a significant contribution of one predictor (sex: $\chi^2_{(2)}$ = 8.944, P= .011; stress: $\chi^2_{(2)}$ = .101, P= .951). In Table 2 the coefficients of predictors sex and anxiety are shown for all levels compared to level 1.

METS classification

For the Item 1 of the self-perceived impact of COVID-19 questionnaire the model was statistically significant ($\chi^2_{(6)}$ = 50.816, $P< .001$), Pseudo R^2= .258, Pearson test indicated a good fit unlike the Deviance test ($\chi^2_{(4)}$ = 11.474, P=.642; $\chi^2_{(4)}$ = 14.183, P= .028) and likelihood ratio tests showed a significant contribution of both predictors (sex: $\chi^2_{(3)}$ = 15.708, P= .001;

Table 1. Descriptive statistics of the response distribution regarding self-perceived impact of COVID-19 on their will and the kind of practiced physical activity

	Question 1	Question 2	Question 3
	n (%)	n (%)	n (%)
0	56 (25.7)	/	/
1	28 (12.8)	45 (20.6)	79 (36.2)
2	79 (36.2)	88 (40.4)	85 (39.0)
3	55 (25.2)	85 (39.0)	54 (24.8)

Table 2. Parameter estimates of the multinomial logistic regression analysis considering anxiety, depression, stress, METS and Sex as predictor variables and as reference category the second level of the answer of self-perceived impact of COVID-19 questionnaire.

Parameter estimates																				
Subgroup anxiety						Subgroup depression						Subgroup stress					METS classification				
Question 1		*P*	OR	95% CI		Question 1		*P*	OR	95% CI		Question 1		*P*	OR	95% CI	Question 1		*P*	OR	95% CI	
				Lower bound	Upper bound					Lower bound	Upper bound					Lower bound	Upper bound				Lower bound	Upper bound
2	Sex (F)	.126	1.81	.846	3.873	2	Sex (F)	.030*	2.202	1.078	4.499	2	Sex (F)	.053	2.043	.991	4.214	2	Sex (F)	.013*	2.689	1.229	5.885
	Anxiety	.054	1.487	.993	2.226		Depression	.092	1.505	.936	2.419		Stress	.036*	1.969	1.044	3.713		METS	.015*	.449	.235	.857
3	Sex (F)	.005*	3.17	1.419	7.084	3	Sex (F)	.001*	3.879	1.802	8.349	3	Sex (F)	.001*	3.565	1.644	7.733	3	Sex (F)	<.001*	5.176	2.052	13.057
	Anxiety	.022*	1.587	1.069	2.356		Depression	.010*	1.84	1.156	2.929		Stress	.007*	2.367	1.271	4.405		METS	<.001*	.221	.113	.431
4	Sex (F)	.041*	3.119	1.049	9.276	4	Sex (F)	.009*	4.074	1.427	11.634	4	Sex (F)	.005*	4.441	1.587	12.428	4	Sex (F)	.020*	3.664	1.230	10.919
	Anxiety	.004*	1.986	1.247	3.162		Depression	<.001*	2.948	1.726	5.035		Stress	.028*	2.239	1.09	4.599		METS	<.001*	.219	.102	.473
Question 2						Question 2						Question 2						Question 2					
2	Sex (F)	.032*	2.08	1.063	4.069	2	Sex (F)	.007*	2.403	1.276	4.525	2	Sex (F)	.014*	2.234	1.18	4.232	2	Sex (F)	.560	.817	.414	1.613
	Anxiety	.17	1.265	.904	1.771		Depression	.567	1.119	.761	1.648		Stress	.142	1.478	.878	2.488		METS	.544	.863	.536	1.39
3	Sex (F)	.796	1.118	.481	2.599	3	Sex (F)	.291	1.519	.699	3.301	3	Sex (F)	.298	1.511	.695	3.287	3	Sex (F)	.202	.589	.261	1.328
	Anxiety	.002*	1.873	1.267	2.77		Depression	.001*	1.991	1.304	3.039		Stress	.005*	2.267	1.282	4.010		METS	.497	.82	.462	1.455
Question 3						Question 3						Question 3						Question 3					
2	Sex (F)	.367	1.416	.665	3.017	2	Sex (F)	.273	1.484	.733	3.005	2	Sex (F)	.21	1.577	.773	3.218	2	Sex (F)	.521	.778	.362	1.674
	Anxiety	.535	1.123	.777	1.623		Depression	.497	1.151	.768	1.725		Stress	.911	.969	.560	1.676		METS	.994	1.002	.574	1.748
3	Sex (F)	.014*	2.425	1.197	4.913	3	Sex (F)	.003*	2.699	1.391	5.237	3	Sex (F)	.003*	2.732	1.397	5.342	3	Sex (F)	.937	.972	.483	1.959
	Anxiety	.336	1.174	.847	1.627		Depression	.654	1.088	.752	1.576		Stress	.834	1.053	.651	1.703		METS	.359	.797	.490	1.296

OR: odds ratio; CI: confidence interval; F: Female; METS: Metabolic Equivalent of Tasks; *: significance with $P < .05$.

METS classification: $\chi^2_{(3)} = 27.739$, $P < .001$). For the Item 2 the model was not statistically significant ($\chi^2_{(4)} = 1.939$, $P = .747$), Pseudo $R^2 = .012$, Pearson and Deviance test indicated a good fit ($\chi^2_{(4)} = 2.403$, $P = .662$; $\chi^2_{(4)} = 2.467$, $P = .651$) and likelihood ratio tests did not show a significant contribution of the predictors (sex: $\chi^2_{(2)} = 1.635$, $P = .442$; METS classification: $\chi^2_{(2)} = .588$, $P = .745$). For the Item 3 the model was not statistically significant ($\chi^2_{(4)} = 1.702$, $P = .790$), Pseudo $R^2 = .010$, Pearson and Deviance test indicated a good fit ($\chi^2_{(4)} = 6.896$, $P = .141$; $\chi^2_{(4)} = 8.408$, $P = .078$) and likelihood ratio tests did not show a significant contribution of the predictors (sex: $\chi^2_{(2)} = .467$, $P = .792$; METS classification: $\chi^2_{(2)} = 1.066$, $P = .587$). In Table 2 the coefficients of predictors sex and anxiety are shown for all levels compared to level 1.

Discussion

The results obtained here suggest that even if all three dimensions of the psychological factors examined contributed to the observed patterns, depression showed the most consistent and statistically robust association with perceived reduction in PA in the post-acute phase of the pandemic, a period when direct public health restrictions had been eased but psychological consequences were still being felt. However, this relationship is likely bidirectional: lower levels of PA may exacerbate depressive symptoms, while depression itself may reduce motivation for PA[26]. In addition, anxiety was also a significant predictor, showing greater variability across the three different questions, reflecting the nuanced relationship between anxiety and PA. In this context, researchers have conducted a study in which an inverse relationship was found between anxiety and PA frequency[27]. As depression and anxiety are psychological variables that have had particularly pronounced effects during the COVID-19 pandemic[2,28], especially in adolescents[25], it can be inferred that the reduced propensity to perform PA could be a long-term consequence of this increase[18,29].

The pandemic has reinforced this correlation. Studies show that reduced PA during lockdown has exacerbated mental health problems[4]. Although the model for the anxiety subscale in question 3 (i.e. *Thinking on sport/physical activities before COVID-19, do you believe that the pandemic has […]*) does not show good agreement, the results obtained seem to be in line with the literature. In fact, women are more likely to report that the pandemic has had a negative impact on motivation to engage in PA/exercise than women who do not see an impact of the pandemic. Our regression analyses revealed that gender significantly predicted perceived reductions in PA in several models, with female participants more likely to report negative changes, particularly in relation to depression and stress (Table 2). These findings are consistent with existing literature suggesting that female adolescents have been disproportionately affected by the psychological consequences of the pandemic[17,30]. Although our study was not primarily designed to examine gender-specific effects, the observed pattern supports previous evidence of increased vulnerability of female adolescents during health crises.

Consistent with our findings, the literature shows that the percentage of adolescents testing positive for depressive symptoms increased during the pandemic, with the increase being greater in females[28]. Furthermore, research consistently shows that anxiety during the COVID-19 pandemic also disproportionately affected females compared to males. Researchers studying Chinese social media users during the pandemic found that women were significantly more likely to suffer from anxiety than men[31]. This suggests a possible long-term impact of COVID-19 on PA in adolescents, which to our knowledge has not yet been adequately researched. It could be hypothesized that this association is due to avoidance of the physiological sensations of movement, which can be interpreted as anxiety and/or panic[32].

From what has been said so far, a long-term relationship between anxiety, stress, depression and the frequency of PA can be inferred. However, it is important to recognize that the observed associations do not necessarily imply causality. The relationship between PA and psychological distress is dynamic and possibly reciprocal, which is also supported by meta-analytic evidence[7] for the frequency of PA, at least in adolescents. In this context, it is important to emphasize that the result of the variance residuals does not seem to be able to effectively capture the contribution of each individual in relation to the expected values, although the Pearson test shows a good fit of the model. This could be due to the sample size, which, although large, may not be sufficient to fully capture the PA level of the reference population before the pandemic. Nevertheless, it is worth noting that PA levels derived from the IPAQ significantly predicted perceived changes in activity in response to the first question. However, this predictive relationship weakened for subsequent questions, likely due to the fact that they relied more on subjective comparisons and motivational self-evaluations than specific behavioral recollections

The IPAQ data showed that more than half of the adolescents (97 out of 187) were rated as "High active", yet a significant proportion reported a perceived decrease in their PA level. Interestingly, IPAQ categorization significantly predicted perceived change for the first question only ("*Do you believe your activity is lower than before COVID-19?*"), but not for questions relating to motivation or intensity. This discrepancy illustrates the well-known divergence between measured behavior and self-perception, especially in adolescents. Supporting this interpretation, a study by Polito and collaborators[33] on PA levels in the general Italian population reported a median of 1154 MET-min/week among individuals aged 18–30, markedly lower than the 2760 MET-min/week calculated in our sample.

Such differences may reflect an overestimation of PA in our adolescents, likely influenced by internal factors such as mood, self-esteem, or cognitive biases that, in turn, may influence the evaluation of one's activity independently of actual exercise patterns, a phenomenon widely discussed in the health psychology literature[34]. This may reflect the complex interplay between objective activity levels and subjective perceptions, where factors such as motivation and mental health may overshadow actual PA in determining self-reported change[22].

It is also important to emphasize that perceived reductions in PA may not accurately reflect actual behavioral changes. Because both the IPAQ and the DASS-21 are based on self-report, they are inherently susceptible to social desirability bias, particularly in the adolescent population. Participants may have overestimated their PA or downplayed their psychological distress to achieve a socially acceptable self-report, potentially inflating the associations between reported mental health and PA levels. Previous research has shown that individuals who self-report often exaggerate their PA engagement and respond in a way that portrays themselves positively[34]. This bias may be partly responsible for the discrepancies between perceived and measured activity. It may be particularly pronounced in women, who report higher levels of stress but are also more sensitive to social norms regarding health and behavior.

Practical Applications

As demonstrated here, it is useful to administer psychological and physical tests in schools in order to constantly monitor the well-being of students. The results justify the implementation of each physical education lesson with mindfulness sessions that can help students take care of their mental sphere, next to the physical one, exploiting the activation of the body and the synaptic plasticity window induced by activity. Finally, given that the mental variables and the poor basic physical fitness drive the predictive model, it seems useful to build multidisciplinary teams who can translate screening results into individualized physical activity programmes and follow-up paths, creating a continuous feedback system at the service of students' well-being.

Conclusions

This study shows the ongoing psychological and behavioral impact of the COVID-19 pandemic on adolescents. Anxiety and depression were significantly associated with a perceived reduction in PA, suggesting that psychological distress may influence the way adolescents evaluate their behavior after the pandemic. The coherence between subjective perceptions and IPAQ-based activity levels emphasizes the importance of mental health in interpreting PA patterns. These findings support the need for integrated interventions targeting both emotional well-being and PA engagement. Finally, longitudinal studies are needed to clarify directional relationships and develop effective recovery strategies.

Limitations of the study

This study has several limitations. First, the sample included only final-year high school students, which limits generalizability to younger adolescents, who may differ in terms of developmental level, emotional vulnerability, and behavioral regulation. Second, both psychological distress (DASS-21) and PA levels (IPAQ) were assessed using self-report tools, which carries the risk of recall and social desirability bias. This may have led to participants overestimating their activity or downplaying psychological symptoms. In addition, the self-assessment questions were retrospective assessments of pre-pandemic behavior, which are particularly susceptible to memory bias and mood-related reconstructions. These biases may have influenced both the direction and the strength of the observed correlations. While the IPAQ provided standardized indicators of current activity, the discrepancies between reported behavior and perceived change reflect the complexity of measuring PA. As mentioned in the literature[35], the reliability of even objective instruments varies depending on the methodology used. We therefore support the integration of multimodal approaches (e.g. accelerometry, ecological snapshot and biomechanical instruments) in future studies to increase the validity of the measurements. Furthermore, the cross-sectional design hinders causal inferences. Although we observed significant associations between mental health and changes in PA, longitudinal studies are needed to determine the temporal direction and to control for potential confounding factors such as previous mental health status, socioeconomic environment, and access to recreational activities. Finally, the study did not examine contextual or sociodemographic variables such as socioeconomic status, access to recreational spaces, or family environment, all of which may act as confounders. These elements may influence both mental health and PA behavior, and their omission limits the ability to fully interpret the observed relationships. Future studies should incorporate more comprehensive ecological indicators to capture the complex interplay between individual, social and environmental determinants of adolescent health.

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Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Ethical Committee approval

Ethics Committee of the Faculty of Kinesiology, University of Split, Split, Croatia (approval number: 2181-205-02-05- 24-0021).

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The authors have no conflicts of interest to declare.

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Authors contribution

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