




# Impact of COVID-19 on the physical activity, quality of life and mental health of adolescent athletes: a 2-year evaluation of over 17 000 athletes

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## ABSTRACT

**Purpose** To evaluate the changes in mental health, quality of life (QOL) and physical activity (PA) among adolescent athletes during the COVID-19 pandemic as organised sports resumed.

**Methods** Adolescent athletes completed surveys including demographic and sport participation information, 7-item Generalized Anxiety Disorder, 9-item Patient Health Questionnaire, Pediatric Quality of Life Inventory and the Hospital for Special Surgery Pediatric Functional Activity Brief Scale in May 2020 following COVID-19-related sport cancellations (Spring20) and after returning to sports in May 2021 (Spring21). The groups were balanced by inverse propensity score weighting and compared using analysis of variance models and ordinal regression models.

**Results** 17 421 participants were included (Spring20=13 002; Spring21=4419; 16.2±1.2 years; 53% female). Anxiety was significantly lower (better) in Spring21 (Spring20=7.0, 95% CI 6.9 to 7.1; Spring21=4.9, 95% CI 4.8 to 5.0, p<0.001), as was the prevalence of moderate to severe anxiety (Spring20=29.4%, Spring21=17.1%, p<0.001). Depression was significantly improved in Spring21 (Spring20=7.6, 95% CI 7.5 to 7.7; Spring21=4.6, 95% CI 4.5 to 4.8, p<0.001), as was the prevalence of moderate to severe depression (Spring20=32.2%, Spring21=15.4%, p<0.001). Athletes in Spring21 reported higher QOL (Spring20=79.6, 95% CI 79.3 to 79.9; Spring21=84.7, 95% CI 84.4 to 85.0, p<0.001) and increased levels of PA (Spring20=13.8, 95% CI 13.6 to 13.9; Spring21=22.7, 95% CI 22.6 to 22.9, p<0.001).

**Conclusion** Early COVID-19 sports restrictions were associated with worsening mental health in adolescents. In 2021, after returning to sports, athletes reported significant improvements in mental health, QOL and PA, although mental health adversities remain an important priority.

## INTRODUCTION

Sport participation is recognised to have positive influences on the health and well-being of adolescents.<sup>1-3</sup> Although sports may carry a risk of injury for some participants, and the risks of single-sport specialisation and professionalisation are increasingly recognised, organised sports remain the primary vehicle for physical activity (PA) among children in the USA. In addition to increased PA and the associated cardiac, bone and metabolic health

## WHAT IS ALREADY KNOWN ON THIS TOPIC?

⇒ Adolescent athletes reported high levels of depression and anxiety, and low levels of physical activity (PA) and quality of life (QOL) early in the COVID-19 pandemic.

## WHAT THIS STUDY ADDS?

⇒ In 2021, after returning to sports, athletes reported significant improvements in mental health, QOL and PA.  
⇒ While PA levels in Spring 2021 were similar to prepandemic levels, the reported levels of anxiety, depression and QOL remain worse than previously reported values among adolescents before COVID-19.

## HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY?

⇒ This study highlights the adverse impact of pandemic-related exercise restrictions on adolescents and can help inform future decisions regarding sports participation, especially in the midst of an ongoing mental health epidemic.  
⇒ Despite the benefits of sports participation, adolescent athletes continue to report higher levels of depression and anxiety than before the COVID-19 pandemic, suggesting that mental health needs remain a priority in this population.

benefits, organised sport participation is associated with improved mental health, quality of life (QOL), academic achievement and reduced stress, substance misuse and risk-taking behaviour.<sup>4,5</sup> Recognising these benefits, in 2019 the Department of Health and Human Services released the National Youth Sports Strategy, a nationwide call to action to reduce barriers to access and expand opportunities for organised sport participation to all US children.<sup>6</sup>

Unfortunately, during the widespread cancellation of sports across the USA early in the COVID-19 pandemic, adolescent athletes throughout the country reported markedly high levels of anxiety and depression.<sup>7,8</sup> Specifically, among a cohort of over 13 000 athletes from across the country, 37% reported moderate to severe levels of anxiety and 40% reported moderate to severe levels of depression. Certain populations of adolescent athletes



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appeared to be disproportionately impacted, with female athletes, older athletes, team sport athletes and athletes from areas of greater poverty reporting lower PA and QOL, and greater levels of anxiety and depression.<sup>7</sup> In a separate study of the subset of these athletes from Wisconsin, these outcomes were compared with data collected from Wisconsin athletes prior to COVID-19. In addition to dramatic decreases in PA and QOL, the prevalence of moderate to severe depression had increased from under 10% to over 33%.<sup>8</sup> This impact is not unique to adolescent athletes, however, and is consistent with the impacts of COVID-19 restrictions on populations of children and adolescents,<sup>9</sup> collegiate student-athletes,<sup>10,11</sup> performing arts students<sup>12</sup> and elite athletes.<sup>13</sup>

During the 2020/2021 academic year, many organisations throughout the USA were able to reinstate sport participation for children and adolescents. In a prior study, we have found that adolescent athletes able to return to sport in Fall 2020 reported lower levels of anxiety and depression, as well as increased PA and QOL compared with those who are unable to return.<sup>8</sup> However, this research has been limited to athletes from a single state from Fall 2020, and it remains unclear how the resumption of sports has influenced the physical and mental health of adolescent athletes through the USA later in the pandemic through 2021. We are aware of no prior research that has evaluated any changes in mental and physical health among US adolescent athletes during the reinstatement of organised sports following the initial cancellations in response to the COVID-19 pandemic.

Therefore, the purpose of this study was to evaluate the changes in mental health, QOL and PA among adolescent athletes across the USA. To measure this impact, we compared self-report data on anxiety, depression, QOL and PA from athletes who had returned to sports in May 2021 with similar data that our study team collected from a nationwide cohort of adolescent athletes in May 2020.<sup>7</sup> We hypothesised that adolescent athletes who had returned to sports in 2021 would report lower levels of anxiety and depression, improved QOL and increased PA than athletes reported when sports were cancelled early in the COVID-19 pandemic.

## METHODS

Adolescent athletes in grades 9 through 12 throughout the USA (male and female, aged 13–19) were recruited to complete an anonymous online survey through a link distributed via social media postings and emails sent to high school administrators throughout the country that shared the posting. Although not involved in the development of the study, stakeholders in youth sports who received the survey link (coaches, administrators, athletes, families, etc) were able to aid in the distribution to others if interested. Within the survey link, adult participants were able to provide informed consent based on information provided regarding the study purpose, risks and benefits. Minor participants provided informed assent after reading the information regarding the study's purpose and design and obtaining permission from their parent and/or guardian to participate. Participants and the public were not involved in the design or conduct of the study.

Interested adolescents who self-identified as having participated in organised sports prior to the COVID-19 pandemic completed an anonymous online survey in April to June 2021. The online survey included 69 questions that included the participant's age, sex, grade, as well as a list of all the sports they played since summer 2020. The remainder of the survey consisted of an assessment of mental health, QOL and PA level

as described below. Data collected in the Spring 2021 (Spring21) were compared with the data collected from a similar cohort of adolescent athletes during the Spring 2020 (Spring20) when sports were cancelled.<sup>7</sup>

## Mental health

The 7-item Generalized Anxiety Disorder (GAD-7) and 9-item Patient Health Questionnaire (PHQ-9) surveys were used to evaluate anxiety and depression symptoms experienced in the past 2 weeks, respectively.<sup>14,15</sup> The GAD-7 scale is a 7-item measure of anxiety symptoms that has demonstrated good test–retest reliability (intraclass correlation=0.83), internal consistency (Cronbach's  $\alpha$ =0.92), as well as criterion and construct validity.<sup>16</sup> It has previously been found to be able to differentiate between mild and moderate GAD in adolescents.<sup>14</sup> Scores range from 0 to 21 with a higher score indicating increased anxiety. In addition to the total score, GAD-7 categorical scores of 0–4, 5–9, 10–14 and 15–21 correspond to no, mild, moderate and severe anxiety symptoms, respectively. The PHQ-9 is a 9-item measure that has been found to have good test–retest reliability (intraclass correlation=0.84), internal consistency (Cronbach's  $\alpha$ =0.89) and criterion and construct validity.<sup>17</sup> It has demonstrated high sensitivity and specificity for depression screening in adolescent patients aged 13–17 years.<sup>15</sup> The PHQ-9 scores range from 0 to 27 with a higher score indicating a greater level of depression symptoms. In addition to the total score, PHQ-9 categorical scores of 0–4, 5–9, 10–14, 15–19 and >20 correspond to minimal or none, mild, moderate, moderately severe and severe depression symptoms, respectively.

## Quality of life

QOL was measured with Pediatric Quality of Life Inventory 4.0 (PedsQL), which has been shown to be a valid measurement of QOL in children and adolescents,<sup>18,19</sup> and used in adolescent athletes throughout the COVID-19 pandemic.<sup>8,20,21</sup> The PedsQL questionnaire assesses QOL for the previous 7 days and contains 23 items. A physical summary score (physical function) and psychosocial (emotional, social and school functions) summary score can be calculated, as well as the total PedsQL scores. Each of these three scores ranges from 0 to 100 with a higher score indicating better QOL.

## Physical activity

PA level was assessed with the Hospital for Special Surgery Pediatric Functional Activity Brief Scale (HSS-PFABS).<sup>22</sup> This instrument contains eight items to measure the activity of children between 10 and 18 years old during the past month, yielding scores ranging from 0 to 30 with a higher score indicating greater PA. The HSS-PFABS has demonstrated test–retest reliability (intraclass correlation coefficient=0.91), internal consistency (Cronbach's  $\alpha$ =0.914)<sup>23</sup> and convergent and discriminant validity in adolescent populations.<sup>23–25</sup> In addition, it has been used in prior work to evaluate PA among adolescents during the COVID-19 pandemic.<sup>8,20,21</sup>

## Statistical analyses

Statistical analyses were performed for participants who provided a valid, complete survey. Participants were excluded if they (1) did not complete the entire survey or (2) were not in grades 9–12. Participants in the Spring21 cohort were included if they had returned to participation in at least one organised sport. Demographic variables were summarised (mean (SD) or n (%)) by group (Spring20, Spring21). Comparisons between groups were made via analysis of variance (ANOVA) for continuous variables or  $\chi^2$  tests for categorical

variables. To allow for meaningful comparisons between the two groups, we weighted the analyses based on the inverse propensity score weighting (IPSW), which is an accepted method for making meaningful comparisons between groups in which important characteristic differences are present. Specifically, the propensity score is the probability of each individual being included in one group or another (Spring20, Spring21) based on the individual characteristics included. The IPSWs are then calculated as the inverse from these propensity scores and applied to the study population to appropriately weight the data such that these potentially confounding characteristics are controlled for in the analyses. Briefly, the addition of the IPSW to the final models adjusts for the characteristic differences between the two groups to mitigate the potential bias introduced by the fact that the groups are not formed randomly and allow for meaningful statistical comparisons.<sup>26</sup> Variables in the propensity score model included age, region of the USA (West, Southwest, Midwest, Southeast and Northeast), school size (total student enrolment), median household income, number of high school and club sports and sport type (individual, team or both).

Means and 95% CIs for each cohort were estimated by separate ANOVA models for anxiety, depression, QOL and PA. Ordinal logistic regression models were used to estimate the proportion (95% CI) of each cohort within the different levels of anxiety (GAD-7) and depression (PHQ-9). Post hoc comparisons were made with Tukey's honestly significant difference adjustment. We recognise that the cohorts may have differences in participant characteristics, which often occur in non-randomised observational studies that seek to document the changes in health among various populations. The methodology we used is similar to multiple prior publications from various countries documenting the changes in mental health among various populations before and during the COVID-19 pandemic.<sup>27–29</sup> The analyses were conducted in R for statistical computing with statistical significance set a priori at  $p < 0.05$ . The data collected are the result of efforts to facilitate survey completion by dissemination through email, word of mouth and social media. As a result, all complete responses received were included but do not represent a prespecified sample size.

Our study reports PA, QOL and mental health outcomes from adolescent athletes inclusive of all genders, race/ethnicities, geographic locations within the USA and socioeconomic levels. Our interdisciplinary author team consisted of four women and five men from different areas (sports medicine, kinesiology, epidemiology, psychiatry, biostatistics), including one junior scholar and one athletic trainer. Data collection was similar in all cases and we did not alter methods based on regional, educational or socioeconomic differences of the individual reporting the information. The potential influences of gender, socioeconomic status, school size, geographic location and age are included as variables in the propensity score model presented in the statistical analysis.

## RESULTS

Four thousand three hundred and forty-six athletes (age =  $16.1 \pm 1.3$  years, female = 52.1%) provided completed surveys. The responses from this cohort were compared with responses from adolescent athletes in the Spring20 cohort ( $n = 13\,002$ , age =  $16.3 \pm 1.2$ , female = 53.0%). Due to the convenience sampling design, the total number of individuals who received the survey is unknown, and a response rate cannot be determined. The participant characteristics for the two cohorts are shown in table 1. Statistically significant differences between the groups were identified with respect to several participant characteristics, including age, grade, school enrolment, region, number of sports played, socioeconomic status and type of sport played. Consequently, these variables were

**Table 1** Characteristics of adolescent athletes in Spring 2020 and Spring 2021

Variable	2020 (n=13 002)	2021 (n=4419)	P value
Sex (male)	6117 (47.0%)	2106 (47.9%)	0.338
Age (years)*	16.3 (1.2)	16.1 (1.3)	<0.001
Grade (%)			<0.001
9th	3089 (23.8)	1209 (27.4)	
10th	3419 (26.3)	1103 (25.0)	
11th	3743 (28.8)	1161 (26.3)	
12th	2751 (21.2)	946 (21.4)	
Region* (%)			<0.001
Midwest	9124 (70.2)	2935 (66.4)	
Northeast	279 (2.1)	440 (10.0)	
Southeast	946 (7.3)	349 (7.9)	
Southwest	146 (1.1)	393 (8.9)	
West	2507 (19.3)	302 (6.8)	
School enrolment*	864 (412–1515)	793 (358–1382)	<0.001
Funding—public (%)	11 327 (87.3)	3896 (88.2)	0.152
County poverty (%)	11.6 (4.2)	11.5 (4.8)	0.019
County under 18-year poverty (%)	15.1 (6.5)	14.9 (7.6)	0.362
County median house income*	63 653 (14 318)	66 101 (17 007)	<0.001
Number of high school sports	1.9 (0.8)	1.9 (0.9)	0.815
Number of total sports*	2.7 (1.1)	2.2 (1.2)	<0.001
Sport type* (%)			<0.001
Individual	2252 (17.3)	922 (20.9)	
Team	6257 (48.1)	2578 (58.3)	
Both	4493 (34.6)	919 (20.8)	

Data presented as mean (SD) or n (%).

\*Variables included as inverse propensity score weight in models comparing outcomes in the two groups.

included as IPSW in the models to compare outcomes between the two groups.

A comparison of the reported anxiety, depression, QOL and PA for the two cohorts is shown in table 2. Specifically, the Spring21 participants reported lower (better) GAD-7 scores for anxiety and PHQ-9 scores for depression than Spring20 participants. Similarly, the participants in the Spring21 cohort were less likely to report moderate to severe symptoms of anxiety (Spring20 = 29.4%, Spring21 = 17.1%,  $p < 0.001$ ; see figure 1) or depression (Spring20 = 32.2%, Spring21 = 15.4%,  $p < 0.001$ ; see figure 2) than athletes in the Spring20 cohort. Compared with Spring20, the Spring21 cohort reported significantly improved QOL and higher levels of PA.

## DISCUSSION

This study builds on prior research that has identified the serious mental health crisis experienced by adolescents in general during the COVID-19 pandemic,<sup>8 21</sup> and additionally identifies the important role that organised sports can play to improve the physical and mental health of adolescent athletes. Our results suggest that the reinitiation of sport participation for adolescents is associated with significant improvements in mental health, QOL and PA. While the two groups are not composed of the same individuals and there are important differences between the Spring20 and Spring21 groups, we have attempted to account for these through the use of IPSW models including the variables that differed between the groups. This is in agreement with our prior cross-sectional research in the Fall 2020 showing that athletes able to return to sports reported markedly lower anxiety and depression, and significantly higher



**Table 2** Characteristics of adolescent athletes in Spring 2020 and Spring 2021

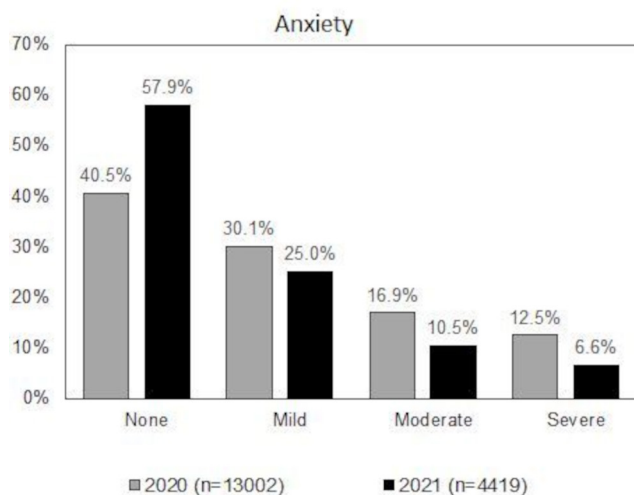
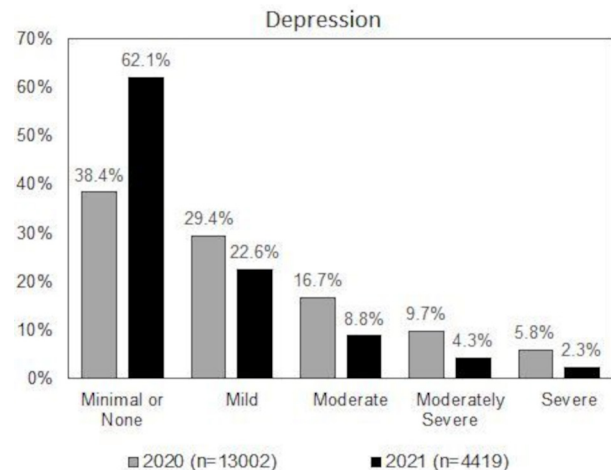
Variable	2020 (n=13002)	2021 (n=4346)	P value
GAD-7 total score	7.0 (6.9, 7.1)	4.9 (4.8, 5.0)	<0.001
GAD-7 categories (%)			
None	40.5 (39.7, 41.3)	57.9 (57.0, 58.7)	
Mild	30.1 (29.5, 30.7)	25.0 (24.5, 25.6)	
Moderate	16.9 (16.4, 17.4)	10.5 (10.1, 10.9)	
Severe	12.5 (12.0, 13.0)	6.6 (6.3, 6.9)	
PHQ-9 total score	7.6 (7.5, 7.7)	4.6 (4.5, 4.8)	<0.001
PHQ-9 categories (%)			
Minimal or none	38.4 (37.6, 39.2)	62.1 (61.3, 62.9)	
Mild	29.4 (28.8, 29.9)	22.6 (22.1, 23.1)	
Moderate	16.7 (16.1, 17.2)	8.8 (8.4, 9.1)	
Moderately severe	9.7 (9.3, 10.2)	4.3 (4.0, 4.5)	
Severe	5.8 (5.5, 6.2)	2.3 (2.2, 2.5)	
PFABS total score	13.8 (13.6, 13.9)	22.7 (22.6, 22.9)	<0.001
PedsQL			
Physical score	84.7 (84.5, 85.0)	88.3 (88.0, 88.6)	<0.001
Psychosocial score	76.8 (76.5, 77.1)	82.7 (82.4, 83.1)	<0.001
Total score	79.6 (79.3, 79.9)	84.7 (84.4, 85.0)	<0.001

Data presented as mean (SD) or n (%).  
 GAD-7, 7-item Generalized Anxiety Disorder; PedsQL, Pediatric Quality of Life Inventory; PFABS, Pediatric Functional Activity Brief Scale; PHQ-9, 9-item Patient Health Questionnaire.

QOL and PA than athletes who had not returned to sports, even after adjusting for age, gender, school instructional delivery type and socioeconomic status.<sup>20</sup> In light of the coincident adolescent mental health and physical inactivity epidemics that have been exacerbated by the COVID-19 pandemic,<sup>30</sup> these data suggest that sport participation may represent a vital tool to improve adolescent health.

### Mental health

Athletes in the Spring21 group reported lower anxiety than those in Spring20, both in terms of the total GAD-7 score and the prevalence of higher categorical levels of anxiety. While 29% of the participants in Spring20 reported moderate to severe anxiety, this had decreased to 17% in Spring21. Unfortunately, we are unaware of prior

**Figure 1** Differences in levels of anxiety (from Generalized Anxiety Disorder-7) between adolescent athletes during COVID-19 cancellations in Spring 2020 and after returning to sports in Spring 2021.**Figure 2** Differences in levels of depression (from 9-item Patient Health Questionnaire) between adolescent athletes during COVID-19 cancellations in Spring 2020 and after returning to sports in Spring 2021.

research in a comparable sample of adolescent athletes regarding anxiety prior to COVID-19 for comparison. Nonetheless, nearly one in five of the adolescent athletes in our study continue to report clinically significant levels of anxiety, which are higher than those reported among other groups of athletes using the same measure prior to COVID-19.<sup>31 32</sup> Similarly, athletes in Spring21 reported fewer symptoms of depression than athletes in the Spring20 group, with respect to both the total score and the prevalence of different levels of depression from the PHQ-9. Whereas only 15.4% of the athletes in Spring21 reported moderate to severe depression symptoms, 32% in Spring20 reported a similar degree of symptoms. This improvement in mental health between the Spring20 and the Spring21 is consistent with prior research suggesting the psychosocial benefits of sport participation for adolescent athletes.<sup>4 33-35</sup> While we are not aware of prior research evaluating depression in a nationwide sample of adolescent athletes prior to COVID-19, the prevalence of moderate to severe depression in a large cohort of adolescent athletes from a single state was less than 10%.<sup>8</sup> This suggests that while mental health appears to have improved among adolescent athletes in the USA in Spring21, the levels of depression identified in Spring21 in the current study continue to be higher than historic levels.

Unfortunately, the adolescent mental health crisis that existed prior to 2020 has been exacerbated by the COVID-19 pandemic.<sup>9 36 37</sup> While the various factors felt to account for the paediatric mental health epidemic prior to the onset of COVID-19 are beyond the scope of the present study, in recent months the American Academy of Pediatrics, the American Academy of Child and Adolescent Psychiatry and the Children's Hospital Association have declared a national mental health emergency for children based on rising emergency department visits for mental health crises and suicide attempts.<sup>38</sup> Our early research suggested that adolescent athletes reported very high levels of anxiety and depression following the cancellation of sports in Spring20.<sup>7</sup> While this may have been a consequence of a number of concomitant factors present at the time, our current research suggests that the return to sports is associated with significant improvements in anxiety and depression, and may represent an important tool to improve mental health in adolescents. While we are not able to identify the specific elements of sport participation that may be responsible for these improvements, several mechanisms have been suggested to explain the relationship

between PA and mental health, including improvements in physical self-perception, self-confidence and perceived competence that lead to enhanced self-esteem.<sup>39</sup> In addition, organised sports may influence mental health and well-being through psychosocial mechanisms such as the restoration of athletic identity, social connections and support, and role models.<sup>10 35</sup>

### Quality of life

Among adolescent athletes throughout the USA, we found that QOL improved significantly from Spring20 to Spring21. The Spring21 group reported higher global QOL, as represented by the total score from the PedsQL, and they reported similarly higher physical and psychosocial QOL. This is consistent with prior research that has found that QOL scores are higher among athletes compared with non-athletes.<sup>40 41</sup> These results are also consistent with prior research showing higher QOL among adolescent athletes who had returned to sports in Fall 2020 compared with those who had not.<sup>20</sup> In addition to increased PA, the increase in QOL following the reinitiation of sports in our current study may be attributable to the psychosocial benefits of sport participation, such as social interaction, emotional support and the re-establishment of role models and athletic identity.

Unfortunately, the total PedsQL scores reported by the Spring21 participants remain lower than those reported prior to the COVID-19 pandemic.<sup>41 42</sup> In fact, the QOL scores in Spring21 were similar to those reported by non-athletes prior to the pandemic.<sup>41 42</sup> This suggests that while the opportunity to return to sports can significantly improve physical, psychosocial and global QOL among athletes, it may be insufficient to restore the level of QOL seen among athletes prior to the COVID-19 pandemic. This may be due in part to a number of other factors affecting adolescents in general, such as ongoing or intermittent school closures, learning modifications, loss of social interactions and economic impacts associated with the COVID-19 pandemic that are not accounted for in this study.

### Physical activity

PA has wide-ranging beneficial effects on a number of health outcomes in adolescents, including sleep, academic success, well-being and mental health.<sup>34 43</sup> Decreased PA in adolescents may also have long-term negative effects in terms of increased risk for obesity and cardiometabolic disease.<sup>43 44</sup> We found that adolescent athletes in Spring21 report large increases in PA compared with athletes in Spring20. Importantly, the scores reported in Spring21 were similar to previously published normative adolescent data ( $22.7 \pm 20.2$ ).<sup>22</sup> Consistent with research among athletes in the early pandemic,<sup>8 21</sup> ongoing research has continued to document the consequences of decreased paediatric PA during the COVID-19 pandemic. For example, although body mass index among children had been increasing prior to COVID-19, the rate of increase during the pandemic has been found to be nearly twice as high.<sup>45</sup> In addition, this increase in obesity during adolescence may represent a risk factor for the development of depression in young adulthood.<sup>46</sup> In light of the worsening childhood obesity epidemic, public health stakeholders should consider the promotion of sport participation as an important opportunity to promote PA and undermine the long-term negative health consequences of decreased PA during the COVID-19 pandemic.

### Limitations

This study has several limitations. The data presented here were self-reported from online surveys and not the result of a clinical examination. Nonetheless, our findings are consistent with the reports and methodologies employed by others during the COVID-19

pandemic to define the changes in physical and mental health.<sup>37 47</sup> In light of the online survey delivery, our sample may be biased towards participants from higher socioeconomic cohorts with easier access to internet services. We did not include non-athletes within our sample, which could limit our ability to generalise the findings beyond the athletic population. In addition, because our surveys were completed anonymously and the two groups are not composed of the same individuals, differences in outcomes between the cohorts could have been influenced by other confounding variables related to both time and the outcomes which were not accounted for in our analysis. However, the use of IPSW in the models allowed for adjustment and balancing of the groups with respect to a number of known potential confounders, similar to prior longitudinal research during the COVID-19 pandemic. Nonetheless, these limitations highlight the need for additional research to identify additional factors that may impact the health of adolescent athletes during the COVID-19 pandemic in addition to sport participation.

### CONCLUSION

Adolescent athletes reported significant impairments in mental health, QOL and PA in the Spring20 when sports were cancelled. In 2021, after returning to sports, athletes reported significant improvements in mental health, QOL and PA. Although the reported levels of PA have returned to prepandemic levels, the levels of depression and QOL remain worse than previously reported values among adolescents before the COVID-19 pandemic. This suggests that while sport participation may have a significant and beneficial impact on psychosocial outcomes, the impacts of the COVID-19 pandemic on the mental health and well-being of young athletes will remain an important consideration into the future. Future research can help identify adolescent athletes at risk and evaluate the role of additional interventions to improve well-being and mental health.

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**Patient consent for publication** Not applicable.

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**Data availability statement** Data are available upon reasonable request.

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