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Do sports protect us from COVID-19? An evaluation of COVID-19 infection, vaccination status, and cardiac examination findings in children who exercise

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Original Article

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Abstract

Aim: The COVID-19 pandemic which has devastated the whole world for the past 3 years affects different patient groups differently. This study aims to evaluate the prevalence, symptoms, and severity of COVID-19 infection, vaccination status, and cardiac pathologies of children who exercise. *Material and methods:* The records of the children and adolescents who applied to our paediatric cardiology outpatient clinic for preparticipation examinations between 01.01.22 and 31.12.2022 were scanned retrospectively, and information about their COVID-19 history, the severity of infection, symptoms during the infection, at the time of the examination, and vaccination status was obtained. The results were analysed using MS Excel 2016 software. *Results:* The study consisted of 240 children [82 (34.17%) girls and 158 (65.83%) boys] whose mean age was 12.64 ± 2.64 years, mean weight was 50.03 ± 15.53 kg, mean height was 157 ± 15.09 cm, and mean body mass index was 19.65 ± 3.59. 129 cases had a COVID-19 history, 74 cases had no COVID-19 history, and 37 only had contact but no polymerase chain reaction positivity. 84 cases were mild, 19 were moderate, and 12 were asymptomatic. The most common symptoms were fatigue, malaise, headache, sore throat, and fever. 51 cases (35.15%) were vaccinated against COVID-19. No significant cardiac pathologies were detected in electrocardiography or echocardiography *Conclusions:* This study shows that COVID-19 infections in children who exercise are generally mild and self-limiting. Our findings suggest that exercise may have positive effects on immunity.

Introduction

After originating in Wuhan, China, COVID-19 was soon declared a worldwide pandemic by the World Health Organization. As of May 31, 202, after more than three years since the declaration of the pandemic, the World Health Organization has claimed that the total number of cases was 767,364,883 and the total death toll was 6,938,353. Although the infection's prevalence has significantly decreased, new cases are still being reported.[1]

Although the infection was thought to manifest mild and asymptomatically in children during the early days of the pandemic, later on, severe forms of the disease such as Multisystem Inflammatory Syndrome in Children, which presents with a clinical picture similar to Kawasaki syndrome, and persisting forms like long COVID were observed.[2] Numerous different approaches were suggested for protection against the infection and for minimising its secondary effects. One of these was exercise, whose effect on infections and immunity has long been discussed.[3,4] It has been stated that exercise not only reduces the adverse psychological and mental impact of the pandemic but also has a positive influence against the infection and its forms like long COVID.[5,6] Most of the studies exploring the relationship between exercise and COVID-19 have focused on how athletes can protect themselves from COVID-19 and how to safely return to exercising after being infected;[7–11] however, not many studies have investigated the impact of exercise against COVID-19 in the paediatric population yet. Hence, this study was conducted to evaluate the prevalence, symptoms, and severity of COVID-19 infection, vaccination status, and cardiac pathologies of children who exercise.

Materials & method

This single-centred retrospective study consists of 240 children and adolescents who have applied to our paediatric cardiology outpatient clinic for preparticipation examinations between 01.01.22 and 31.12.2022. The records of the cases were scanned retrospectively, and information about their COVID-19 history, the severity of infection, symptoms during the infection, and at the time of the examination, and vaccination status was obtained. The cases were divided into

three groups: the ones who had a COVID-19 history, the ones who didn't have a COVID-19 history, and the ones who had contact with infected family members but no polymerase chain reaction (PCR) positivity. At the time of their examination, the cases who had a COVID-19 history were also asked about their clinical symptoms and hospitalisation status during the infection. Since children over 12 years of age are vaccinated in our country, the vaccination status of the cases who were older than 12 was investigated.

The severities of the COVID-19 infection were classified as asymptomatic, mild, moderate, severe, and critical

a. Asymptomatic: The cases that had a positive PCR test result but had no clinical symptoms.
b. Mild: The cases that had fatigue, malaise, headache, myalgia, self-limiting symptoms of upper respiratory tract, and gastrointestinal system infection (sore throat, cough, naso-pharyngeal congestion, anosmia, ageusia, nausea, vomiting, and diarrhoea).
c. Moderate: The cases that had symptoms such as dyspnoea, chest pain, shortness of breath, hypoxaemia, pneumonia, and fever that persisted for more than 1 week.
d. Severe: The cases that required hospitalisation and oxygen therapy without ventilation.
e. Critical: The cases that required ventilation.

The cases who had gotten the COVID-19 infection at least one month prior to the preparticipation examination were included in the study. They were asked what kind of complaints they had, if any, at the time of the examination.

The cases were inquired about how many years and how many hours per week they have been exercising. The sports were classified as strength (tae kwon do, judo, karate, wrestling, boxing, kickbox, fitness), endurance (climbing, athleticism, swimming, swimming, running, triathlon, rowing), team sports (football, volleyball, basketball, handball), and technical discipline (gymnastics, ballet, tennis, table tennis).

The weights, heights, and blood pressures of all cases included in the study were recorded during their examination. Their body mass index and percentiles were calculated. Electrocardiography and echocardiography were performed, and their results were evaluated for all cases. The blood pressures were measured using the oscillometric blood pressure device (Mindray, PM 9000) with cuffs suitable for their ages. The electrocardiograms were taken with the Cardiovit AT-102 plus (Schiller) device. Echocardiography was performed by a single cardiologist using the Vivid S6 (GE Healthcare Systems) device, and the structural and functional cardiac pathologies were evaluated. The evaluations were done according to the guidelines of the American Society of Echocardiography. The conventional measurements were taken with M mode.

All statistical analyses and tests were performed using SPSS version 28 (IBM SPSS Statistics) on a personal computer. The normality of variable distribution was assessed with the Shapiro–Wilk test. P values<0.05 were considered statistically significant. Group comparisons were performed with the Kruskal–Wallis (COVID-19 positive, negative, contact). Spearman's rho correlation analyses were applied. The charts were produced using MS Excel 2016.

The approval reports were taken from the Ethics Committee of Zeynep Kamil Women and Children's Diseases Training and Research Hospital (22.02.2023/ No 33). The Helsinki Declaration was adhered to during the study.

Results

The study consisted of 240 children of which 82 (34.17%) were girls and 158 (65.83%) were boys. Their ages ranged between 5 years 7 months and 17 years 9 months. The mean age was 12.64 ± 2.64 years. The mean weight of the cases was 50.03 ± 15.53 kg, the mean height was 157 ± 15.09 cm, and the mean body mass index was 19.65 ± 3.59. 27 (10.22%) cases were below the 5th body mass index percentile, 100 (43.37%) cases were in the 5–50th percentiles, 84 (35.59%) were in the 50-95th percentiles, and 25 (10.59%) were above the 95th percentile.

The exercise duration of the cases ranged between 1 month and 13 years, with the mean duration being 2.94 ± 2.83 years. The weekly hours of exercise ranged between 1 and 25 hours per week, and the mean was 5.57 ± 4.15 hours. 151 (62.92%) cases participated in sports that were classified as "team sports," 29 (12.08%) in "strength," 26 (10.83%) in "endurance," 5 (2.08%) in "technical discipline," and 29 (12.08%) participated in more than one sport.

129 (53.75%) of the cases had a history of COVID-19 infection and 111 (46.25%) cases did not. Among the cases who had a history of COVID-19, 9 cases had gotten the infection twice and 1 case three times. Among the cases who did not have a history of COVID-19, 74 had neither gotten the infection nor had contact with infected individuals, while 37 had contact with infected family members but had a negative PCR test result and no clinical symptoms. The descriptive findings of the cases based on sex and COVID-19 history status are presented in Table 1.

At the time of the preparticipation examination, at least 1 and at most 33 months (mean: 12 months) had passed since the cases had gotten the COVID-19 infection. The clinical findings of the cases during their COVID-19 infection are given in Table 2, and the severity of the infection is given in Figure 1. Three cases (2.33%) were kept under observation for a short period either in the hospital or the emergency room for symptomatic treatment. The complaints of the cases that were recorded during the preparticipation examination were similar among all three groups (COVID-19 history, no COVID-19 history, contact only), as shown in Table 3.

Since children under the age of 12 years were not vaccinated against COVID-19 in Turkey, there were 142 cases older than 12 years in our study group who could potentially get the vaccine. 79 of these cases had a COVID-19 history. 51 cases (35.15%) had gotten at least one shot of the COVID-19 vaccine. The vaccination status of 8 cases was unknown. The distribution of the cases older than 12 years according to their vaccination status, COVID-19 history, and sex is presented in Table 4.

Mild structural cardiac pathologies were detected in the echocardiography findings. Patent foramen ovale was observed in 7 cases, mitral valve prolapse +/− mild mitral insufficiency in 4 cases, bicuspid aortic valve insufficiency +/− aorta insufficiency in 4 cases, and increased trabeculations in the left ventricle in 1 case. The M mode measurements and systolic functions measured in the echocardiogram were within the normal range. The electrocardiograms showed normal sinus rhythm, and only one case had extrasystole. The blood pressure values and electrocardiography and echocardiography findings of the cases are given in Table 5.

A statistically significant difference ($p < 0.05$) between the COVID-19 history status of the cases and their ages (0.704), heights (0.912), weights (0.753), body mass index (0.443), and body mass index percentiles (0.196) wasn't found.

There was not a statistically significant relationship between COVID-19 infection status and the number of hours per week and

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Table 1. Distribution of cases according to COVID-19 status and sex

		COVID −		COVID +		Contact	
		Girl (n = 26)	Boy (n = 48)	Girl (n = 41)	Boy (n = 88)	Girl (n = 15)	Boy (n = 22)
Age (year)	ort ± SD	12,69 ± 2,77	12,55 ± 2,53	13,38 ± 2,35	12,48 ± 2,74	12,36 ± 2,01	12,18 ± 3,17
	Min–Max	7.58–17.16	6.25–16.66	8.42–17.33	6.66–17.75	9.50–16.83	5.58–16.00
Weight (kg)	ort ± SD	46,18 ± 11,54	49,89 ± 14,89	50,10 ± 12,13	51,34 ± 18,57	50,58 ± 11,06	49,17 ± 16,46
	Min–Max	20.00–72.00	21.20–86.40	23.60–81.00	21.40–125.00	32.50–71.00	20.00–90.00
Height (cm)	ort ± SD	155,46 ± 11,06	158,35 ± 15,66	158,49 ± 10,27	158,06 ± 17,09	156,04 ± 9,70	156,77 ± 20,28
	Min–Max	129.00–170.00	123.00–184.00	133.00–175.00	120.50–190.00	138.00–173.00	112.00–186.00
Body mass index	ort ± SD	18,82 ± 3,26	19,52 ± 3,81	19,70 ± 3,35	19,87 ± 3,97	20,60 ± 3,13	19,35 ± 2,55
	Min–Max	12.02–27.10	13.55–28.32	13.34–27.70	12.78–34.99	15.36–27.39	14.83–26.01
Body mass index percentile	ort± SD	37,73 ± 32,01	44,02 ± 32,52	44,29 ± 33,19	50,71 ± 32,81	60,46 ± 32,26	47,65 ± 28,70
	Min–Max	0.16–97.61	1.22–99.38	0.38–99.98	0.02–99.73	3.07–98.61	6.43–98.34

Table 2. Distrubution of clinical findings during COVID-19 infection

n = 112	n	%
Fever	70	62,50
Fatigue	87	77,68
Headache/ Malaise / Sore throat	74	66,07
Cough	47	41,96
Vomiting / Stomach ache	10	8,93
Diarrhoea	11	9,82
Skin rash	1	0,89
Ocular findings	5	4,46
Syncope	3	2,68
Anosmia / Ageusia	22	19,64
Nasal congestion / Rhinitis	23	20,54

Table 3. Complaints at the time of the preparticipation examination

Findings	COVID-19−	COVID-19 +	Contact	Total
Fatigue	5	4	4	13
Chest pain / Malaise	11	2	1	14
Shortness of breath	5	2	1	8
Dizziness / Syncope	4	2	2	8
Palpitation	2	2	–	4
Bradycardia	1	–	–	1
Total	28	12	8	48

total number of years of exercise (Spearman's rho: 0.037, p = 0.584).

SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, QTc: corrected Qt interval in electrocardiogram, PR: PR interval on electrocardiogram, HR: heart rate per minute, LVDD: left ventricular diastolic diameter. EF: Ejection fraction, SF: shortening fraction, LA/ Ao: left atrial to aortic root ratio, IVSD: interventricular septal diameter, LVPWD: left ventricular posterior wall diameter.

Table 4. COVID-19 infection and vaccination status in children athletes over 12 years old

	COVID −		COVID +		Contact		
	Girl	Boy	Girl	Boy	Girl	Boy	Total
No Vaccine −	8	17	18	26	7	9	85
Vaccinated +	6	9	10	18	2	4	49
Unknown	0	1	1	6	0	0	8
Total	14	27	29	50	9	13	142

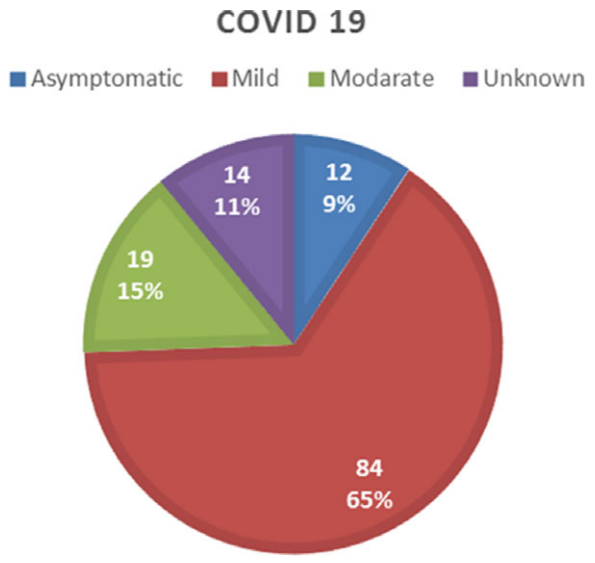

Figure 1. Severity of COVID-19 Infection.

Discussion

The impact of exercise on infections and the immune system is a matter of debate.[1,2,12] The duration, frequency, and intensity of exercise are important factors that modulate the influence of exercise on immunity. It has been stated that moderate-intensity exercise 3 days per week plays a positive role in immunity whereas doing high-intensity exercises for a long period of time has an adverse effect and may increase the susceptibility to upper

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Table 5. Distribution of blood pressure, electrocardiography, and echocardiography findings of the cases

		n	Mean	StdDev	Min	Max
Blood pressure	SBP (mmHg)	239	112,04	9,98	82,00	150,00
	DDB (mmHg)	239	69,14	8,29	40,00	96,00
Electrocardiogram	Qtc (msn)	238	412,46	19,57	353,00	461,00
	PR (msn)	234	130,42	16,62	76,00	184,00
	HR (per min)	238	86,88	14,84	49,00	130,00
Echocardiogram	LVDD (mm)	240	44,24	4,30	34,16	58,00
	EF (%)	240	67,05	4,79	57,00	80,00
	SF (%)	240	37,15	3,88	30,00	49,00
	LA/Ao	239	1,18	0,12	0,91	1,55
	IVSD (mm)	240	8,60	1,54	5,00	12,48
	LVPWD (mm)	240	8,47	1,43	5,00	13,14

respiratory tract infections,[13] which can also potentiate the risk of COVID-19 infection. It is generally thought that moderate exercise has a positive impact on the prognosis of COVID-19, recovery, and post-COVID syndrome.[13] Smer et al. have claimed that during the pandemic, exercise status prior to COVID-19 infection was inversely correlated to hospitalisation duration.[14] Moderate exercise for at least 150 minutes per week or vigorous exercise for 75 minutes per week was stated to decrease the prevalence of COVID-19 by 3.43%.[15]

In their study that included 147 COVID-19-positive elite international athletes, Hull et al. have reported that the most common symptoms of the infection were fatigue (57%), dry cough (50%), and headache (46%).[16] Similarly, in our study group, fatigue (77.68%), malaise, headache, sore throat (66.07%), and fever (62.5%) were observed the most (Table 3). Studies have suggested that the prognosis of COVID-19 infection was mild in 82% and asymptomatic in 16% of elite athletes.[17] In a study done in Italy, among the 45 children athletes between the ages of 9 and 18 included in the study, the infection was asymptomatic in 55.5% and mild in 44.5% of the cases, and one MIS-C case was diagnosed.[18] In a meta-analysis encompassing 38 studies and 3062 cases in total, the total ratio of asymptomatic cases was reported as 11.9%.[19] In our study 65% of the cases were mild, 15% were moderate, and 9% were asymptomatic. 3 cases had applied to the emergency room for symptomatic treatment but had no history of hospitalisation. 11% of the cases only reported that they had a COVID-19 infection but no information could be retrieved regarding the symptoms and severity of their infection. Krzywanski et al. have put forth that symptomatic cases were more common among male athletes, whereas asymptomatic cases were more common among women;[17] however in our study, we did not observe a significant difference in the presence of clinical symptoms based on sex.

Cafiero et al. have stated that the COVID-19 infection is generally self-limiting and mild in the paediatric population and does not tend to cause short and medium-term cardiorespiratory problems.[18] Likewise, the cases in our study mostly had a self-limiting and mild infection period.

No significant cardiac pathologies were detected in the electrocardiograms and echocardiograms of the cases. Only a few cases required Holter and effort tests, but no pathologies were found in these tests either. Erickson et al. have reported that among the 170 college student-athletes over the age of 18 years who had mild symptoms of COVID-19, 4% had mild electrocardiographic changes while 9.4% were referred to a cardiologist but myocarditis was not detected in any.[20] According to 15 eligible studies which consist of 6229 athletes in total, the prevalence of myocarditis was reported to range between 0.4% and 15.4%,[21] whereas another meta-analysis has reported it as 1–4%.[22] Some studies have stated that overall 2,3 %.of the MR findings of elite athletes indicate clinical or subclinical myocarditis;[23] however, none of our cases had myocarditis or MIS-C, although the possibility cannot be totally ruled out as the MR findings of our cases were not evaluated.

The prevalence of long COVID among the 46 million COVID-19 cases in the U.S. was reported as 23%.[24] In our study, no significant difference in the complaints at the time of the preparticipation examination was noted between the cases who had a history of COVID-19 infection and those who did not, as shown in Table 3. This led us to think that the complaints were not related to COVID-19, also as supported by the study of Cafiero et al.[18]

Vaccination against COVID-19 not only protects elite athletes from the infection but also significantly reduces the duration of the period when they are prohibited from participating in sports.[25,26] One study has reported that exercising consolidates the immune response to the COVID-19 vaccine in autoimmune rheumatic disease patients who receive immune suppressive treatment.[27] Extrapolating from these results, it may be inferred that exercise can potentiate the vaccine response in healthy children athletes as well, hence reducing the risk of COVID-19 infection. The vaccination rate of the cases older than 12 years in our study was low (35.15%) which can be attributed to various factors such as cultural differences, anxiety and fear of the families, and hesitations about the side effects of the vaccine. A clear conclusion regarding the effect of vaccination cannot be reached in this study due to the lack of standardisation in the type and number of the vaccine and the time of vaccination (before or after COVID-19 infection).

To conclude, our study has demonstrated that COVID-19 infections in children and adolescents who exercise are generally mild and self-limiting. No significant cardiac pathologies were detected either in echocardiography or electrocardiography. Although it is commonly accepted that children tend to have a milder clinical picture of COVID-19, our findings suggest that exercise may also have positive and protective effects on immunity.

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Limitations and future directions

The fact that this is a retrospective and observational study that included cases of different age groups who participated in different types of sports for different exercise durations and that the clinical findings of COVID-19 were recorded solely based on anamnesis are among the limitations of this study. Another limitation of our study is that self-limiting COVID-19 infections in children are poorly understood despite our findings, and it is difficult to differentiate between the effect of exercise and a naturally greater or more efficient immune response on the severity of infection. A strength of this study is that it focuses on COVID-19 infections in children who exercise, considering that currently studies that delve into this topic are scarce. This study emphasises the importance of understanding the relationship between exercise and immunity in the paediatric population, especially with regard to the COVID-19 pandemic, which may be beneficial in giving wing to further research in this field as well as contributing to the data pool which can be used to create optimal guidelines for sports in the future. More multicentred prospective studies that evaluate the impact of exercise on both the short-term and long-term effects of COVID-19 in children are required to fully elucidate this topic.

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Author contributions. The corresponding author Nurdan Erol has done the planning and design of the study, performed the cardiac examinations of the cases, gathered the data, and wrote this manuscript. Çiğdem Erol has done the statistical analysis and interpreted the results. The manuscript has been read and approved for submission by both authors.

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