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Sex Differences in The Impact of COVID-19 Restrictions on Physical Fitness Changes Among Slovenian Schoolchildren

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Abstract

The COVID-19 pandemic and its related restrictions profoundly disrupted opportunities for physical activity among children worldwide, raising concerns about potential impacts on their physical fitness. This study investigated sex differences in changes of physical fitness among Slovenian schoolchildren before and during the pandemic (6th and 8th grade). Using a retrospective observational design, we analyzed data from the national SLOfit surveillance system, comparing two cohorts: a pre-pandemic group (tested in 2017 and 2019) and a pandemic group (tested in 2019 and 2021). Analyses of covariance were conducted to examine changes over time and differences between sexes in 8th grade, adjusting for 6th grade performance. A total of 1553 children (746 pre-pandemic, 807 pandemic) were included. Boys consistently outperformed girls in tests of muscular strength, explosive power, coordination, and endurance, while girls performed better in flexibility. In the pre-pandemic cohort, boys largely maintained or improved their performance, whereas girls showed stagnation or decline, particularly in cardiorespiratory endurance (600 m run test: 146.8 s for boys vs. 168.7 for girls; $p<0.001$). In the pandemic cohort, boys jumped on average 189.9 cm compared to 168.0 cm in girls, completed 47.7 vs. 42.3 sit-ups, and finished the 600 m run in 156.1 s vs. 174.1 s (all $p<0.001$), while girls reached 50.7 cm vs. 40.6 cm in the stand-and-reach test ($p<0.001$). These patterns persisted even after adjustment for anthropometric variables, suggesting that the observed performance gaps are not solely explained by morphological differences but may reflect unequal opportunities for skill development during public health restrictions. The relative magnitude of between-sex differences became more pronounced for tapping, standing long jump, polygon backwards, and stand-and-reach, while narrowing slightly for the 60- and 600-meter run. These findings emphasize the importance of equitable and sex-sensitive physical activity to maintain children's motor competence and physical fitness during societal disruptions.

Keywords: *pandemic restrictions, motor competence, gender differences, youth fitness*

Introduction

The COVID-19 pandemic resulted in unprecedented societal disruptions worldwide, significantly impacting various aspects of public health (Jurak et al., 2021; Kovacs et al., 2021). Several systematic and scoping reviews documented widespread declines in children's physical activity—ranging from approximately 11 to 91 minutes per day—during the pandemic, with sex, age, and socioeconomic status emerging as key determinants (Ng et al., 2020). In a large sample across 17 European and Central Asian countries, the World Health Organization reported increased screen time and decreased physical activity among children aged 7–9, alongside a rise in overweight prevalence (World Health Organization [WHO], 2024). School closures, remote education, and restrictions on outdoor activities limited children's opportunities for regular physical activity, potentially leading to substantial declines in

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physical fitness and motor development (Chambonniere et al., 2021; Pietrobelli et al., 2020; Wunsch et al., 2022).

Recent studies have documented declines in physical fitness among schoolchildren associated with pandemic-related measures. For instance, Chambonniere et al. (2021) observed a significant deterioration in cardiorespiratory endurance, strength, and coordination among French children following the first wave of COVID-19. Similarly, Jarnig et al. (2022) reported decreased aerobic fitness and increased obesity prevalence among Austrian schoolchildren due to pandemic restrictions. Pajek (2022) conducted a retrospective observational study, showing a pronounced decline in various physical fitness indicators, including aerobic endurance, muscular endurance, and motor coordination, between pre-pandemic and pandemic generations of schoolchildren. Direct Slovenian data revealed alarmingly reduced participation in organized and school-based physical activity during lockdown. For example, during remote schooling only 4.3% of Slovenian children received at least 45 minutes of physical education, while extracurricular sports participation dropped sharply from over 70% to more than 80% non-participation (Planinšec et al., 2022). Beyond pandemic-related declines, sex differences in fitness trajectories are well established in pediatric populations. Boys typically demonstrate greater muscle strength, speed, and cardiorespiratory fitness, whereas girls tend to outperform in flexibility and certain coordination tasks (Armstrong & Welsman, 2019; Barnett et al., 2016; Hardy et al., 2010). These disparities are influenced not only by biological and hormonal factors but also by social and environmental determinants such as organized sport participation, cultural expectations, and levels of encouragement from parents and teachers (Riddoch et al., 2004; Sallis et al., 2000).

Although general declines in children's physical fitness during the pandemic are well documented, there is limited evidence regarding potential sex differences in these outcomes. Previous literature indicates significant sex-related differences in physical activity patterns and motor skill development during childhood, suggesting that boys and girls may respond differently to prolonged physical inactivity or limited access to organized physical activities (Barnett et al., 2016; Hardy et al., 2010). Some evidence from Austria and France suggests that girls may have been disproportionately affected, particularly in endurance measures (Chambonniere et al., 2021; Jarnig et al., 2022), while studies from Asia highlight reduced motor competence and increased sedentary behavior among both sexes (Dunton et al., 2020; Ng et al., 2020). Adolescent research indicates that girls perceived more barriers to physical activity during the pandemic, with fewer meeting activity guidelines compared to boys (Mata et al., 2022).

Understanding these differences is crucial for developing targeted strategies aimed at mitigating the negative consequences of reduced physical activity during periods of societal disruption. Therefore, this study leverages the nationally representative SLOfit surveillance system to compare changes in physical fitness (from 6th to 8th grade) between boys and girls in pre-pandemic (2017–2019) versus pandemic-exposed (2019–2021) Slovenian schoolchildren. In addition, to better understand whether observed sex differences could be explained by anthropometric characteristics, we performed regression analyses adjusting for body height, body weight, and triceps skinfold thickness. By focusing on sex-disaggregated changes across key fitness domains, the study aims to elucidate differential vulnerabilities and guide interventions tailored to maintain equitable motor development during societal disruptions.

Materials and methods

Study design and participants

A total of 1553 students (both boys and girls) participated in the study. Of these, 746 were part of the pre-pandemic cohort, having attended the 6th grade during the 2016/2017 academic year. The pandemic cohort consisted of 807 students who began 6th grade in 2018/2019 and experienced COVID-19 containment measures during their 7th and 8th grade years. Basic demographic and anthropometric characteristics collected in the 6th and 8th grade are presented in Table 1.

This retrospective observational study analyzed physical fitness data from Slovenian schoolchildren collected through the national SLOfit surveillance system (Jurak et al., 2020; SLOfit, n.d.). We compared the physical fitness of two cohorts of primary school children. The pre-pandemic cohort was assessed in the 6th grade in 2017 and again in the 8th grade in 2019. In contrast, the pandemic cohort underwent testing in 2019 (6th grade) and in 2021 (8th grade). Unlike the earlier cohort, the pandemic group experienced a significant risk factor during their motor development period—the COVID-19 pandemic, along with its associated public health measures and societal disruptions. The pre-pandemic cohort followed a regular physical education schedule, participating in three hours per week in the 6th grade and two hours weekly in both the 7th and 8th grades. During this time, extracurricular sports and recreational activities took place without interruption. In contrast, the pandemic cohort experienced restrictions and facility closures that significantly limited their participation in sports and physical activity outside of school.

Table 1. Basic demographic and anthropometric characteristics of the included students

Grade	Generation (N)	Age (years)	Male sex (%)	Height (cm)	Weight (kg)	BMI (kg/m^2)
6th grade	Pre-pandemic (N=746)	11.3±0.5	52.5	154.5±7.5	48.6±12	20.2±3.9
	Pandemic (N=807)	11.4±0.5	51	154.2±7.8	47.6±11.8	19.9±3.9
8th grade	Pre-pandemic (N=746)	13.3±0.5	52.5	166.4±7.8	59.8±13.1	21.6±4
	Pandemic (N=807)	13.4±0.5	51	166.6±8.3	60.3±14.1	21.6±4.3

Data were collected from the same students in both 6th and 8th grade.

The SLOfit program annually monitors the physical and motor development of Slovenian children aged 6 to 19 years, with a participation rate exceeding 95% in primary schools (Jurak et al., 2020). Inclusion criteria encompassed schoolchildren in 6th and 8th grade with complete SLOfit data for 2017, 2019 and 2021 assessments. Participants were categorized by sex to examine potential differences in physical fitness changes over the two-year period. Parental consent was obtained for all participants, and the study adhered to ethical standards set

by the Slovenian National Medical Ethics Committee (study approval document ID 102/03/15).

Physical fitness assessment

Physical fitness was evaluated using the standardized SLOfit test battery, which includes three anthropometric measurements and eight motor tests (Jurak et al., 2020; SLOfit, n.d.). Anthropometry comprised body height (measured with a stadiometer to the nearest 0.1 cm), body weight (measured with a calibrated digital scale to the nearest 0.1 kg), and triceps skinfold thickness (assessed with skinfold caliper to the nearest 0.1 mm).

Motor performance was assessed with the following field-based tests: neuromuscular coordination was measured using the 20-second arm-plate tapping test, where participants alternately tapped two discs as quickly as possible. Explosive leg power was evaluated with the standing broad jump, recording the best distance achieved in centimeters. Whole-body coordination was assessed with the polygon course backwards, which required participants to navigate a defined course in reverse as quickly as possible, with time recorded to the nearest tenth of a second. Muscular endurance was evaluated by counting the maximum number of sit-ups performed in 60 seconds, while upper-body muscular endurance was tested with the bent-arm hang, recording how long participants could hold their chin above the bar. Flexibility was assessed using the stand-and-reach test, measuring the maximum reach distance in centimeters. Speed was tested with a 60-meter sprint, timed to the nearest tenth of a second, and cardiorespiratory endurance was measured with the 600-meter run, recording the completion time in seconds.

Data collection procedures

SLOfit assessments were conducted annually in April by trained physical education teachers following standardized protocols to ensure consistency and reliability. Data were recorded and entered into the My SLOfit application, a secure web-based platform designed for data management and feedback dissemination (SLOfit, n.d.). The application uses smart algorithms for data verification and provides individualized reports to students, parents, and educators. The use of these data was approved by the Slovenian National Medical Ethics Committee (document ID 102/03/15) and SLOfit steering committee representative. Informed parental consent was obtained for all participants prior to data collection.

Statistical analysis

Data analysis was performed using SPSS Statistics version 27.0 (IBM Corp., Armonk, NY). Descriptive statistics were calculated for all variables. To assess changes in physical fitness over time and examine sex differences in both cohorts, Analysis of Covariance (ANCOVA) was conducted, with baseline (6th grade) scores as covariates. Effect sizes were calculated using partial eta squared (η^2), with values of 0.01, 0.06, and 0.14 representing small, medium, and large effects, respectively. In a secondary analysis, multiple linear regression models were used to examine the independent effect of sex on 8th grade performance while adjusting for baseline (6th grade) performance and anthropometric variables (height, weight, triceps skinfold). These models allowed us to evaluate whether sex differences persisted after accounting for morphological characteristics. Statistical significance was set at $p<0.05$.

Results

The results of the physical fitness testing at both time points are presented in Table 2.

Table 2. Average values for measured variables in 6th and 8th grade for the whole sample

Test	Geneartion	6th grade	8th grade
Tapping (n)	pre-pandemic	37.8±4.5	42.3±4.8
	pandemic	37.4±4.2	41.7±4.8
Standing long jump (cm)	pre-pandemic	160.3±24.2	179.9±28.3
	pandemic	162.3±23.7	179.4±29.9
Polygon backwards (0.1 s)*	pre-pandemic	139.8±42.5	122.8±36.2
	pandemic	134.3±40.0	126.4±46.1
Sit-ups (n)	pre-pandemic	42.9±9.4	46.9±9.9
	pandemic	42.5±9.9	45.1±10.5
Stand and reach (cm)	pre-pandemic	44.3±8.4	47.2±29.1
	pandemic	43.8±8.4	44.1±30.1
Bent arm hang (s)	pre-pandemic	46.8±29.6	47.6±29.7
	pandemic	49.1±29.8	46.9±30.7
60m sprint (0.1 s)*	pre-pandemic	106.6±11.5	99.3±11.3
	pandemic	106.6±11.2	100.9±12.6
600m run (s)	pre-pandemic	163.1±28.6	157.1±30.7
	pandemic	162.7±27.6	164.5±34.8

*Performance in the polygon backwards and the 60-meter sprint was recorded to the nearest tenth of a second.

Differences in changes between boys and girls

The results for pre-pandemic generation are presented in Table 3. They consisted of 391 boys and 355 girls.

Among schoolchildren assessed before the pandemic, boys showed significantly greater improvements than girls in several fitness components between 6th and 8th grade, including standing long jump, polygon backwards, sit-ups, bent-arm hang, and 60- and 600-meter run. Girls, however, outper-

Table 3. Absolute values of tests for each sex and grade for pre-pandemic generation, analysis of covariance

Test	Sex	6th grade	8th grade	Difference in 8th grade between sexesa (95% CI)	p	Effect size (η^2)
Tapping (n)	Boys	37.6±4.6	42.3±5.0	0.35±0.27 (-0.19 to 0.88)	0.202	0.002
	Girls	38.0±4.4	42.2±4.5			
Standing long jump (cm)	Boys	164.2±24.0	188.2±28.4	11.12±1.23 (8.71 to 13.54)	<0.001	0.103
	Girls	156.1±24.6	170.4±24.9			
Polygon backwards (0.1 s)[b]	Boys	137.1±43.8	119.9±39.0	-3.78±1.63 (-6.98 to -0.57)	0.021	0.008
	Girls	141.9±39.8	126.2±33.3			
Sit-ups (n)	Boys	43.6±9.3	48.9±9.8	3.13±0.56 (2.02 to 4.24)	<0.001	0.042
	Girls	42.2±9.5	44.7±9.5			
Stand and reach (cm)	Boys	40.9±7.0	41.8±7.9	-3.46±0.42 (-4.28 to -2.65)	<0.001	0.089
	Girls	48.0±8.1	51.0±7.7			
Bent arm hang (s)	Boys	34.6±28.2	42.8±28.6	6.67±1.33 (4.06 to 9.28)	<0.001	0.035
	Girls	29.4±23.5	32.1±23.5			
60m sprint (0.1 s)[b]	Boys	105.8±11.7	96.2±11.3	-5.06±0.58 (-6.19 to -3.93)	<0.001	0.106
	Girls	107.9±11.2	102.7±10.3			
600m run (s)	Boys	158.6±26.8	146.8±27.3	-15.71±1.86 (-19.36 to -12.07)	<0.001	0.100
	Girls	170.4±29.9	168.7±30.5			

[a] Difference between sexes in the 8th grade is adjusted for 6th grade performance; [b] Performance in the polygon backwards and the 60-meter sprint was recorded to the nearest tenth of a second; Abbreviations: CI = confidence interval, η^2 = partial eta squared.

formed boys in stand-and-reach test, with a medium effect size (η^2=0.089; p<0.001). No significant sex differences were observed in tapping test.

Next, we investigated the impact of sex on 8th grade performance with additionally adjusting the model for weight, height and triceps skinfold thickness combined with baseline (6th grade) test result (Table 4).

The model for the tapping test explained 42.5% of the variance (R^2=0.425, F(5, 711)=105.5, p<0.001). After adjustment, girls scored on average 0.14 repetitions fewer than boys; however, this difference was not statistically significant (95% CI: -0.71 to 0.43, p=0.637). Among the covariates, performance in the 6th grade was a significant predictor (p<0.001), while body height, body weight, and triceps skinfold thickness were not (p=0.110, p=0.893, and p=0.262, respectively).

The model for the standing long jump test explained 73.4% of the variance (R^2=0.734, F(5, 688)=379.9, p<0.001). After adjustment, boys jumped on average 7.75 cm farther than girls (95% CI: –10.12 to –5.38, p<0.001). Among the covariates, 6th grade performance, body height, and triceps skinfold thickness were significant predictors (all p<0.001, respectively), while body weight was not (p=0.555).

The model for the polygon backwards test explained 68.2% of the variance (R^2=0.682, F(5, 674)=288.5, p<0.001). After adjustment, girls performed on average 1.08 seconds slower than boys; however, this difference was not statistically significant (95% CI: –2.25 to 4.40, p=0.525). Among the covariates, performance in the 6th grade and triceps skinfold thickness were significant predictors (p<0.001 for both), while body height and body weight were not (p=0.051 and p=0.269, respectively).

The model for the sit-up test explained 47.4% of the variance (R^2=0.474, F(5, 683)=123.3, p<0.001). After adjustment, boys performed on average 2.33 more repetitions than girls (95% CI: –3.49 to –1.16, p<0.001). Among the covariates, performance in the 6th grade and triceps skinfold thickness were significant predictors (p<0.001 for both), while body height and body weight were not (p=0.607 and p=0.845, respectively).

The model for the stand and reach test explained 70.4% of the variance (R^2=0.704, F(5, 691)=328.7, p<0.001). After adjustment, girls reached on average 3.92 cm farther than boys (95% CI: 3.05 to 4.80, p<0.001). Among the covariates, performance in the 6th grade, body weight, and triceps skinfold thickness were significant predictors (p<0.001, p=0.011, and p=0.029, respectively), while body height was not (p=0.930).

The model for the bent arm hang test explained 63.5% of the variance (R^2=0.635, F(5, 686)=238.2, p<0.001). After adjustment, boys held the position on average 3.77 seconds longer than girls (95% CI: –6.40 to –1.15, p=0.005). Among the covariates, performance in the 6th grade, body height, body weight, and triceps skinfold thickness were all significant predictors (p<0.001, p<0.001, p=0.012, and p<0.001, respectively).

The model for the 60-meter sprint explained 63.8% of the variance (R^2=0.638, F(5, 633)=222.9, p<0.001). After adjustment, girls were on average 3.23 seconds slower than boys (95% CI: 2.09 to 4.38, p<0.001). Among the covariates, performance in the 6th grade, body height, and triceps skinfold thickness were significant predictors (p<0.001 for all), while body weight was not (p=0.657).

The model for the 600-meter run explained 51.4% of the variance (R^2=0.514, F(5, 621)=131.6, p<0.001). After adjustment, girls were on average 11.19 seconds slower than boys (95% CI: 7.50 to 14.89, p<0.001). Among the covariates, performance in the 6th grade, body height, and triceps skinfold thickness were significant predictors (p<0.001 for all), while body weight was not (p=0.570).

Table 4. Multiple regression results for pre-pandemic generation

Test	R^2	Adjusted sex difference (95% CI)	p-value	Significant covariates
Tapping (n)	0.425	-0.14 (–0.71 to 0.43)	0.637	6th grade performance
Standing long jump (cm)	0.734	7.75 (–10.12 to –5.38)	<0.001	6th grade, height, skinfold
Polygon backwards (0.1 s)[b]	0.682	1.08 (–2.25 to 4.40)	0.525	6th grade, skinfold
Sit-ups (n)	0.474	2.33 (–3.49 to –1.16)	<0.001	6th grade, skinfold
Stand and reach (cm)	0.704	3.92 (3.05 to 4.80)	<0.001	6th grade, weight, skinfold
Bent arm hang (s)	0.635	3.77 (–6.40 to –1.15)	0.005	6th grade, height, weight, skinfold
60m sprint (0.1 s)[b]	0.638	3.23 (2.09 to 4.38)	<0.001	6th grade, height, skinfold
600m run (s)	0.514	11.19 (7.50 to 14.89)	<0.001	6th grade, height, skinfold

[b] Performance in the polygon backwards and the 60-meter sprint was recorded to the nearest tenth of a second.

The results for pandemic generation are presented in Table 5. This group of students consisted of 415 boys and 392 girls.

In the generation affected by COVID-19 restrictions, boys again demonstrated significantly greater improvements across most physical fitness measures compared to girls, with especially large effect sizes in standing long jump (η^2=0.174; p<0.001), while girls outperformed boys in stand and reach test (η^2=0.125; p<0.001). Furthermore, girls showed a deterioration in 600-meter run performance, while boys maintained or improved theirs.

Table 5. Absolute values of tests for each sex and grade for pandemic generation, analysis of covariance

Test	Sex	6th grade	8th grade	Difference in 8th grade between sexesa (95% CI)	p	Effect size (η^2)
Tapping (n)	Boys	44.05±10.55	47.68±10.92	0.92±0.25 (0.43 to 1.42)	<0.001	0.016
	Girls	40.75±8.90	42.29±9.15			
Standing long jump (cm)	Boys	165.51±24.02	189.85±29.85	15.39±1.20 (13.04 to 17.74)	<0.001	0.174
	Girls	158.72±22.88	168.0±25.47			
Polygon backwards (0.1 s)[b]	Boys	135.04±43.99	123.89±52.43	-6.16±2.77 (-11.59 to -0.73)	0.026	0.006
	Girls	133.57±35.14	129.12±38.06			
Sit-ups (n)	Boys	44.05±10.55	47.68±10.92	3.18±0.56 (2.09 to 4.28)	<0.001	0.040
	Girls	40.75±8.90	42.29±9.15			
Stand and reach (cm)	Boys	40.32±7.31	40.59±8.12	-4.28±0.40 (-5.07 to -3.50)	<0.001	0.125
	Girls	47.51±7.73	50.72±7.80			
Bent arm hang (s)	Boys	35.86±28.40	41.91±30.76	6.97±1.28 (4.46 to 9.49)	<0.001	0.037
	Girls	32.93±25.61	32.64±23.67			
60m sprint (0.1 s)[b]	Boys	105.76±12.06	98.31±13.15	-4.09±0.67 (-5.40 to -2.77)	<0.001	0.049
	Girls	107.60±10.15	103.79±11.36			
600m run (s)	Boys	160.25±29.62	156.07±35.05	-13.77±1.89 (-17.47 to -10.06)	<0.001	0.069
	Girls	165.48±24.92	174.09±31.98			

[a] Difference between sexes in the 8th grade is adjusted for 6th grade performance; [b] Performance in the polygon backwards and the 60-meter sprint was recorded to the nearest tenth of a second; Abbreviations: CI = confidence interval, η^2 = partial eta squared.

Next, we investigated the impact of sex with additionally adjusting the model for weight, height and triceps skinfold thickness combined with baseline (6th grade) test result (Table 6).

The model for tapping test explained 46.5% of the variance (R^2=0.465, F(5, 792)=137.6, p<0.001). After adjustment, girls scored on average 0.58 repetitions fewer than boys on the 8th grade tapping test (95% CI: -1.12 to -0.04, p=0.035). Among the covariates, performance in the 6th grade and triceps skinfold thickness were significant predictors (p<0.001), while body height and body weight were not (p=0.584 and p=0.104, respectively).

The model for the standing long jump test explained 74.1% of the variance (R^2=0.741, F(5, 777)=444.5, p<0.001). After adjustment, boys jumped on average 11.51 cm longer than girls (95% CI: 9.14 to 13.87, p<0.001). Among the covariates, 6th grade result, body height, and triceps skinfold were statistically significant predictors (all p<0.001), while body weight was not (p=0.535).

The model for the polygon backwards test explained 53.2% of the variance (R^2=0.532, F(5, 768)=174.47, p<0.001). After adjustment, boys performed on average 3.4 seconds faster than girls; however, this difference was not statistically significant (95% CI: -7.30 to 0.51, p=0.088). Among the covariates, performance in the 6th grade and triceps skinfold thickness were significant predictors (p<0.001), while body height and body weight were not (p=0.137 and p=0.501, respectively).

The model for the sit-up test explained 48.4% of the vari-

ance (R^2=0.484, F(5, 772)=145.03, p<0.001). After adjustment, boys performed on average 2.5 repetitions more than girls (95% CI: 1.34 to 3.69, p<0.001). Among the covariates, performance in the 6th grade and triceps skinfold thickness were significant predictors (p<0.001), while body height and body weight were not (p=0.942 and p=0.263, respectively).

The model for stand and reach test explained 71.4% of the variance (R^2=0.714, F(5, 786)=391.9, p<0.001). After adjustment, boys reached on average 4.86 cm less than girls (95% CI: -5.70 to -4.01, p<0.001). Among the covariates, performance in the 6th grade, triceps skinfold thickness, and body weight were significant predictors (p<0.001, p=0.04, and p=0.001), while body height was not (p=0.790).

The model for the bent arm hang explained 67.0% of the variance (R^2=0.670, F(5, 757)=308.1, p<0.001). After adjustment, girls held the position on average 5.18 seconds less than boys (95% CI: –7.70 to –2.66, p<0.001). Among the covariates, 6th grade performance (p<0.001), body weight (p=0.026), and triceps skinfold thickness (p<0.001) were significant predictors. Body height was not significant (p=0.057).

The model for 60m sprint test explained 56.7% of the variance (R^2=0.567, F(5, 706)=184.6, p<0.001). After adjustment, boys were 1.6 seconds faster than girls (95% CI: -2.98 to -0.28, p=0.018). Among the covariates, performance in the 6th grade, triceps skinfold thickness, and body height were significant predictors (p<0.001, p<0.001, and p=0.003), while body weight was not (p=0.058).

The model for 600m run test explained 54.3% of the variance (R^2=0.543, F(5, 699)=165.8, p<0.001). After adjustment, boys were 9.2 seconds faster than girls (95% CI: -13.11 to -5.39, p<0.001). Among the covariates, performance in the 6th grade, triceps skinfold thickness, and body height were significant predictors (p<0.001, p<0.001, and p=0.009), while body weight was not (p=0.474).

Table 6. Multiple regression results for pandemic generation

Test	R^2	Adjusted sex difference (95% CI)	p-value	Significant covariates
Tapping (n)	0.465	-0.58 (–1.12 to –0.04)	0.035	6th grade, skinfold
Standing long jump (cm)	0.741	11.51 (9.14 to 13.87)	<0.001	6th grade, height, skinfold
Polygon backwards (0.1 s)[b]	0.532	3.40 (–7.30 to 0.51)	0.088	6th grade, skinfold
Sit-ups (n)	0.484	2.50 (1.34 to 3.69)	<0.001	6th grade, skinfold
Stand and reach (cm)	0.714	–4.86 (–5.70 to –4.01)	<0.001	6th grade, weight, skinfold
Bent arm hang (s)	0.670	–5.18 (–7.70 to –2.66)	<0.001	6th grade, weight, skinfold
60m sprint (0.1 s)[b]	0.567	1.60 (–2.98 to –0.28)	0.018	6th grade, skinfold, height
600m run (s)	0.543	9.20 (–13.11 to –5.39)	<0.001	6th grade, skinfold, height

[b] Performance in the polygon backwards and the 60-meter sprint was recorded to the nearest tenth of a second.

Finally, we inspected the relative magnitude of between-sex differences in physical performance between generations. These are shown in the Figure 1. We can see that the between sex difference got larger in pandemic generational results for tapping, long jump, polygon, and stand-and-reach performance. Between-sex differences got slightly lower in 60 and 600-m performance in pandemic generation.

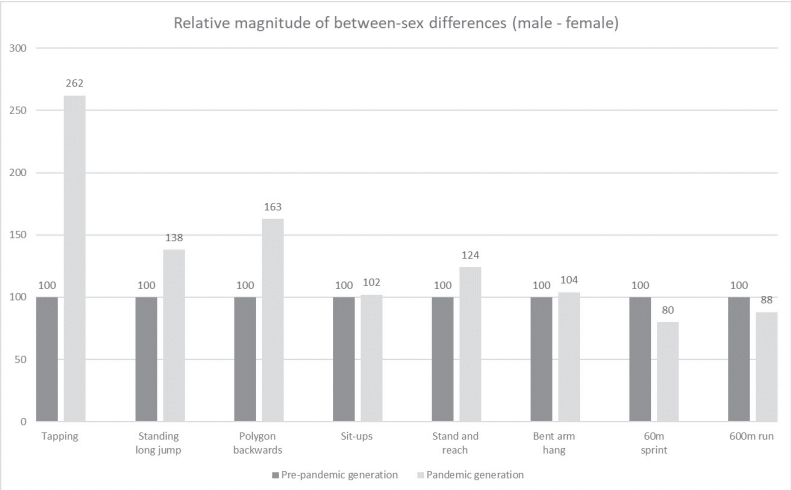

FIGURE 1. Relative magnitude of between-sex differences (in % values)

Discussion

This study investigated sex differences in physical fitness development among Slovenian schoolchildren across two cohorts: one assessed before the COVID-19 pandemic and the other during it. While numerous studies have reported general declines in child physical fitness during the pandemic (Chambonniere et al., 2021; Jarnig et al., 2022), our aim was to determine whether these effects varied by sex. Importantly, we also assessed the relative magnitude of between-sex differences in the pandemic generation compared to the pre-pandemic generation.

Consistent with previous literature, boys outperformed

girls in most physical tests requiring muscular strength, power, and cardiorespiratory endurance, including the standing long jump, bent-arm hang, polygon backwards, sit-ups, and the 60- and 600-meter run, in both the pre-pandemic and pandemic cohorts (Jarnig et al., 2022). These sex-based differences are well documented and have been linked to physiological differences in muscle mass, hormonal profiles, and activity preferences (Handelsman et al., 2018). Girls, on the other hand, consistently performed better than boys in the stand-and-reach test, reflecting greater flexibility (Barnett et al., 2016).

Our regression analyses provide important new insight by showing that these sex differences persisted even after adjusting for anthropometric variables and baseline performance. For example, in both generations, boys maintained significant advantages in explosive power, endurance, and muscular strength, whereas girls retained their advantage in flexibility. These findings suggest that sex gaps cannot be fully explained by body size or composition and instead may reflect behavioral and environmental influences.

Interestingly, the relative magnitude of sex differences became more pronounced in the pandemic generation for several tests (tapping, long jump, polygon backwards, stand-and-reach). This pattern is consistent with studies from Austria and France, which also reported that girls experienced disproportionate declines in endurance and coordination during COVID-19 restrictions (Chambonniere et al., 2021; Jarnig et al., 2022). A possible explanation is that boys may have had greater opportunities or motivation for unstructured physical activity during lockdowns, such as outdoor play or informal sports, while girls were more affected by reduced access to organized and school-based activities. A similar sex disparity was reported in the U.S., where girls perceived more barriers to being active during the pandemic compared to boys (Mata et al., 2022).

The multiple regression results highlight specific mechanisms behind these patterns. In both cohorts, baseline performance strongly predicted 8th grade outcomes, underscoring the importance of early motor competence for later physical fitness (Barnett et al., 2016). Triceps skinfold thickness was a consistent negative predictor across several tests, aligning with evidence that higher adiposity impairs motor performance and endurance (Kwon et al., 2011).

Another novel finding is that sex differences in the 60 m sprint and 600 m run narrowed slightly during the pandemic, although absolute performance declined—especially among girls in the 600 m run, whose mean results worsened from 6th to 8th grade. This pattern may reflect that both sexes were similarly affected in aerobic endurance by restrictions on structured exercise and school sports, as reported in a systematic review showing global reductions in children's cardiorespiratory fitness during the pandemic (Wunsch et al., 2022).

Taken together, our results highlight that the pandemic not only reduced overall physical fitness but also widened certain sex disparities. This finding is consistent with the concept of "amplified inequalities" during crises, whereby vulnerable groups—in this case, girls—are disproportionately affected due to differences in activity opportunities, social support, and perceptions of physical activity (Lopez-Buenoet al., 2020; Ng et al., 2020).

A major strength of this study is the use of high-quality, longitudinal SLOfit data covering nearly the entire Slovenian school-age population, with standardized protocols and repeated measurements. The inclusion of regression models adds robustness, demonstrating that observed sex differences are not merely artifacts of growth or morphology but persist after adjustment for confounders. Additionally, all 8th grade results are adjusted for baseline 6th grade performance which enables us to account for inherent differences between populations at baseline prior to pandemic effects took place and to clearly demonstrate the effects of pandemic disruption on maturation of physical performance. Concerning limitations, we cannot fully account for all confounders such as family environment, motivation, or psychological stress. Additionally, the unique pandemic circumstances may limit the generalizability of these findings to other disruptions. Future research should investigate the underlying behavioral and psychosocial mechanisms that led to divergent responses to pandemic-related disruptions between boys and girls. Moreover, the role of structured vs. unstructured activity in shaping sex-specific fitness development deserves further attention.

Conclusion

This study demonstrated that the COVID-19 pandemic had a differential impact on the development of physical fitness, with sex differences becoming more pronounced in tapping, standing long jump, and polygon backwards performance. This highlights a larger vulnerability of girls to public health disruptions limiting access to physical activity. Importantly, these sex differences persisted even after adjusting for anthropometric characteristics and baseline 6th grade performance, indicating that the observed gaps are likely modifiable and not solely determined by biological sex. These findings emphasize the importance of equitable, inclusive physical education programs that develop children's strength, coordination, and flexibility regardless of sex.

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Conflict of Interest
The authors declare no conflict of interest.

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