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The relevance of the school setting for the development of physical fitness in male adolescents in Chile

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Abstract

The school setting offers adolescents opportunities to engage in physical activity, potentially promoting the normal development of physical fitness. If so, school closure should impair fitness development. We leveraged data from the COVID-19 pandemic to test this idea. We aimed to examine the effects of school closure during the COVID-19 pandemic on the physical fitness of male adolescents from a private school in Chile. Longitudinal records from Physical Education classes were analyzed. The remote-schooling group included 92 boys (median [25th percentile, 75th percentile] age 12.8 [12.5, 13.1] years) measured before school closure due to the pandemic (March 2019) and after reopening (March 2021). The in-person-schooling group included 94 boys (12.7 [12.5, 13.0] years) who were measured in March 2017 and March 2019 and were normally exposed to the school setting. Outcomes included body mass index, maximum oxygen uptake, running speed, sit-ups, standing long jump, and pull-ups. ANOVA was used to test whether changes in the remote-schooling group were different from those in the in-person-schooling group, i.e., group-by-time interactions. Changes in body mass index and pull-ups did not differ between the remote-schooling group and the in-person-schooling group. Nevertheless, compared with the in-person-schooling group, the remote-schooling group showed attenuated increases in maximum oxygen uptake (by 2.5 mL/kg/min), 50-m and 800-m running speed (by 0.4 and 0.8 m/s, respectively), sit-ups (by 4 repetitions), and standing long jump (by 20 cm) (P-interaction < 0.001). School closure thus impaired the normal development of physical fitness in boys from a high socioeconomic background. This highlights the role of schools as health-promoting settings.

Keywords: *Physical Activity; Cardiorespiratory Fitness; Obesity; Exercise Test*

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Introduction

The Ottawa Charter claims that health is built where people live, play, and love (WHO, 1987). Adolescents spend a large proportion of their days in school. Schools should not only convey disciplinary knowledge but also promote healthy habits to foster normal development (UNICEF, 2021). The school setting is thus expected to have a significant influence on adolescents' health by shaping daily routines and offering opportunities for active lifestyles and peer interactions (UNICEF, 2021; WHO & UNESCO, 2021). Testing this idea requires studying adolescents who stopped attending school in person, and therefore partially lost the influence of the setting. School closures during the COVID-19 pandemic offered a natural quasi-experimental design to contrast the effects of exposure versus non-exposure to the school environment on adolescents' health.

Shortly after COVID-19 was declared a global pandemic in March 2020, Chile implemented measures to slow the virus's spread. Schools were closed and remained so throughout 2020, with classes held remotely (Kuzmanic et al., 2023). Sports facilities and public recreational spaces were also closed, and outdoor activities were restricted to specific daytimes. These measures disrupted the routines of children and adolescents, making it hard to maintain regular physical activity, balanced eating, and consistent sleep patterns. Consequently, concerns arose about their overall health, weight status, and physical fitness. Importantly, most studies have examined these effects on disadvantaged populations. There is therefore a gap in understanding how school closure and remote schooling affected adolescents from other socioeconomic backgrounds.

Physical fitness represents a set of attributes that determine the ability to perform physical activities (Ortega et al., 2008). These include cardiorespiratory fitness, muscular fitness, speed, agility, flexibility, and anthropometry (American College of Sports Medicine et al., 2018). Physical activity levels play a key role in maintaining adequate fitness (Zaqout et al., 2016). In this context, schools act as a key environment where adolescents engage in organized sports, develop active habits, and sustain fitness through structured opportunities. Thus, limited access to physical education classes and other school-related recreational activities likely impaired the physical fitness of youngsters during the pandemic. This is particularly concerning in adolescence, a critical period for physical development.

The evidence on the pandemic's impact on physical fitness is mixed. Studies in Spain and Croatia found no changes in cardiorespiratory fitness or body mass index (BMI) shortly after the school closures. Subgroup analyses, however, revealed declines in cardiorespiratory fitness among economically disadvantaged Spanish youth and in muscular fitness among Croatian boys (Medrano et al., 2021; Sunda et al., 2021). A meta-analysis across countries reported average increases in body weight of 2.6 kg and in BMI of 0.77 kg/m^2 during the first five months of the pandemic (Chang et al., 2021). In contrast, a Spanish study found no changes in cardiorespiratory fitness or BMI in adolescents eight months into the pandemic (November 2020) (López-Bueno et al., 2021). Data from the UK showed declines in cardiorespiratory fitness and increases in BMI from November 2019 (pre-pandemic) to November 2020, which were maintained in November 2021 (Basterfield et al., 2024).

These studies highlight the complex effects of school closures on physical fitness in children and adolescents. Importantly, most studies have focused on disadvantaged groups, as they seem to be the most affected by the school closures (Armitage & Nellums, 2020). The impact on adolescents from more favorable socioeconomic backgrounds is less known. Building on this gap, we aimed to examine the effects of school closures on the physical fitness of male adolescents from a private school in Chile.

Methods

Design and setting

This report followed the STROBE guidelines for reporting observational studies (see Supplementary Table 1 for the checklist). This was an observational, analytical, cohort study with a time-matched control group. We analyzed the dataset of physical fitness assessments conducted at a private school in Santiago, Chile. The school is an all-male institution that provides education across twelve grades (ages 6-17 years), with a total enrollment of approximately 1,200 students. The annual tuition fee is approximately 7,500 USD, fully paid by the families. The school is in one of the most affluent communities in the country. In Chile, the academic year starts in March. For this study, we analyzed physical fitness assessments conducted at the beginning of the academic year as part of Physical Education classes. The assessment included cardiorespiratory fitness, speed, muscular strength, and anthropometric measurements.

Participants

We analyzed data from a group of adolescents assessed before the school closure (March 2019; “Before” time point) and after school reopening two years later (March 2021; “After” time point). This group was referred to as the "remote-schooling" group (Figure 1A). Notably, physical fitness is expected to change due to normal growth and development. We therefore included a time-matched control group ("in-person-schooling") for comparison, as has been previously done (Suárez-Reyes et al., 2024). The in-person-schooling group included adolescents assessed in March 2017 (“Before” time point) and again in March 2019 (“After” time point). The in-person-schooling group was matched in time (two years between assessments) and age to the remote-schooling group but was unexposed to the school closure (Figure 1A).

We included the data of male adolescents who had: [a] physical fitness outcomes measured at both time points ("Before" and "After" time points); [b] height and body weight measured at both time points; [c] a signed informed consent form from their parents or guardians; and [d] a signed assent form. The study was approved by the Scientific Ethics Committee of Universidad Finis Terrae, Chile (ID 23-048).

Physical fitness outcomes

Anthropometric measurements included body weight and height. Weight was measured with an electronic scale (Medisana® PSM 40446, China), and height with a stadiometer (Seca® 213, Hamburg, Germany). BMI was calculated as the ratio of body weight to height squared (kg/m^2). BMI z-scores for children aged 5 to 19 were calculated in

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R using the anthroplus package (Schumacher et al., 2011). Weight status was categorized as underweight (BMI z-score < –1.00), healthy weight (BMI z-score from –1.00 to 1.00), overweight (BMI z-score from >1.00 to 2.00), or obesity (BMI z-score > 2.00) (WHO, 2019).

Cardiorespiratory fitness (i.e., maximum oxygen consumption [VO_2max]) was assessed with the Cooper test on a 300-m track. Participants ran or walked for 12 minutes, and the covered distance was recorded. The following equation was used to estimate the VO_2max (mLO_2/kg/min): 22.351 × distance (km) – 11.288 (Cooper, 1968).

Speed was assessed using 50-m and 800-m run tests. Participants were instructed to run as fast as possible over these distances on a track. Time to complete each distance was measured with a stopwatch (Casio® HS 80 TW, China), and average speed (m/s) was calculated as distance divided by time.

Muscle strength was assessed using sit-ups in one minute, standing long jump, and pull-ups. For the sit-up test, participants laid on their backs with their legs bent and arms crossed over their chests. A classmate held their feet on the floor while the participant performed as many sit-up repetitions as possible in one minute. For the standing long jump, participants jumped as far as possible with their feet together, and the distance from toes at take-off to heels at landing was recorded in centimeters. For the pull-up test, participants hung from a horizontal bar with arms fully extended, pulling their bodies upward until the chin surpassed the bar and descending to full elbow extension. Leg swing was not allowed, and the total number of pull-up repetitions was recorded.

Statistics

Analyses were conducted with R (version 4.4.0) in RStudio (version 2024.12.0+467). Lilliefors Kolmogorov-Smirnov was used to test the distribution of numerical variables at the before and after time points (lillie.test function, nortest package (Gross & Ligges, 2015)). Most variables were non-normally distributed. Thus, for consistency, data for all numerical variables are shown as medians with 25th and 75th percentiles. All the values in the Tables and Figures are reported on their original scale. Nevertheless, physical fitness outcomes were log10-transformed for inferential analyses, except for BMI Z-score. ANOVA models were used to test the main effects of group (in-person-schooling versus remote-schooling), time (before versus after, as repeated measures), and their interaction on each physical fitness outcome (aov function, base R). In the case of significant interactions, post-hoc comparisons were conducted between groups at each time point. The Bonferroni method was used to adjust P-values for multiple comparisons (two comparisons: groups at the before and after time points). Of note, changes in the in-person-schooling group are considered the expected response. A significant group-by-time interaction thus indicates that the changes in the remote-schooling group were different from expected. Such a result indicates that the school closure influenced the response of the outcome over the two years. For example, in the case of a significant group-by-time interaction, a smaller increase in the remote-schooling group than in the in-person-schooling group (the expected increase) would indicate that the school closure attenuated the expected increase. Weight status is shown as percentages in each category. Fisher's exact test was used to determine the association between group and weight status at each time point separately. $P < 0.05$ was considered statistically significant.

Results

Figure 1B shows the flowchart for participant selection. In total, 94 male adolescents were included in the in-person-schooling group and 92 in the remote-schooling group. Table 1 summarizes all variables by group and time point.

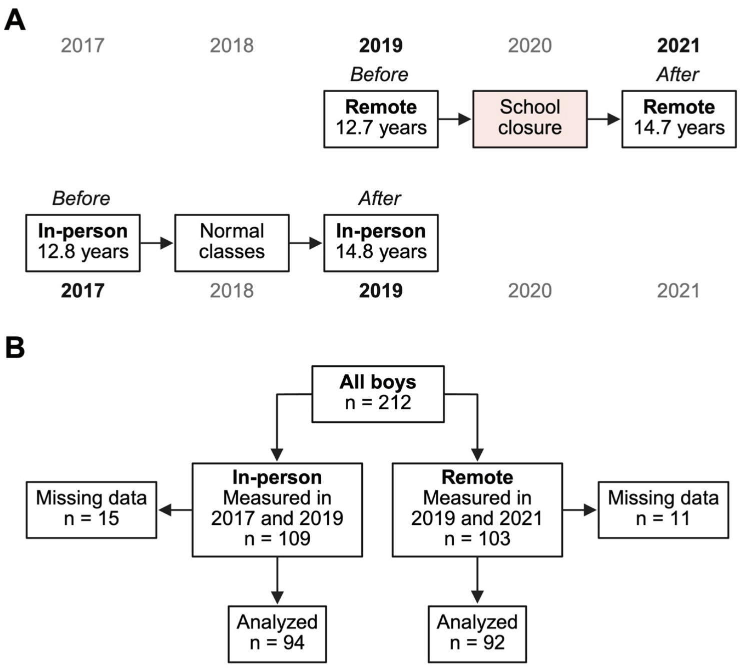

Figure 1. Study design and selection of participants. (A) Time points of the assessments in the remote-schooling group and its time-matched in-person-schooling group. (B) Flowchart for the selection of participants. Created in BioRender. Fernandez verdejo, R. E. (2026) https://BioRender.com/58ykxym.

Table 1. Characteristics of the participants by group and time point.

	In-person-schooling (n = 94)						Remote-schooling (n = 92)					
	Before			After			Before			After		
	Mdn or %	p25	p75	Mdn or %	p25	p75	Mdn or %	p25	p75	Mdn or %	p25	p75
Age, years	12.8	12.5	13.1	14.8	14.5	15.1	12.7	12.5	13.0	14.7	14.5	15.0
Weight, kg	52.1	47.6	56.3	61.4	56.3	65.4	50.5	46.0	55.6	61.3	56.3	65.2
Height, cm	159	154	166	173	169	177	162	156	167	176	172	180
BMI, kg/m^2	20.2	19.0	21.7	20.5	19.1	21.6	19.5	18.2	20.6	20.0	18.7	20.7
BMI, Z-score	0.89	0.43	1.31	0.36	-0.25	0.72	0.61	0.13	0.98	0.17	-0.42	0.46
Weight status												
Underweight, %	1.1	-	-	1.1	-	-	4.3	-	-	9.8	-	-
Healthy weight, %	56.4	-	-	83.0	-	-	72.8	-	-	83.7	-	-
Overweight, %	40.4	-	-	13.8	-	-	22.8	-	-	6.5	-	-
Obesity, %	2.1	-	-	2.1	-	-	0.0	-	-	0.0	-	-
VO_2max, mLO_2/kg/min	44.6	40.0	47.8	49.1	45.2	53.2	45.5	41.0	48.6	46.4	43.5	50.4
50-m speed, m/s	6.1	5.8	6.4	6.9	6.8	7.2	6.0	5.8	6.3	6.7	6.3	7.0
800-m speed, m/s	4.2	4.1	4.4	5.4	4.4	5.6	4.2	4.0	4.4	4.4	4.2	5.2
Sit-ups, repetitions	45	40	49	56	50	61	44	39	49	53	47	58
Standing long jump, cm	167	156	182	221	206	235	180	170	193	224	203	233
Pull-ups, repetitions	4	2	7	8	5	11	3	1	5	6	3	9

All participants are males. BMI, body mass index; Mdn, median; p25, 25th percentile; p75, 75th percentile; VO_2max, maximum oxygen uptake.

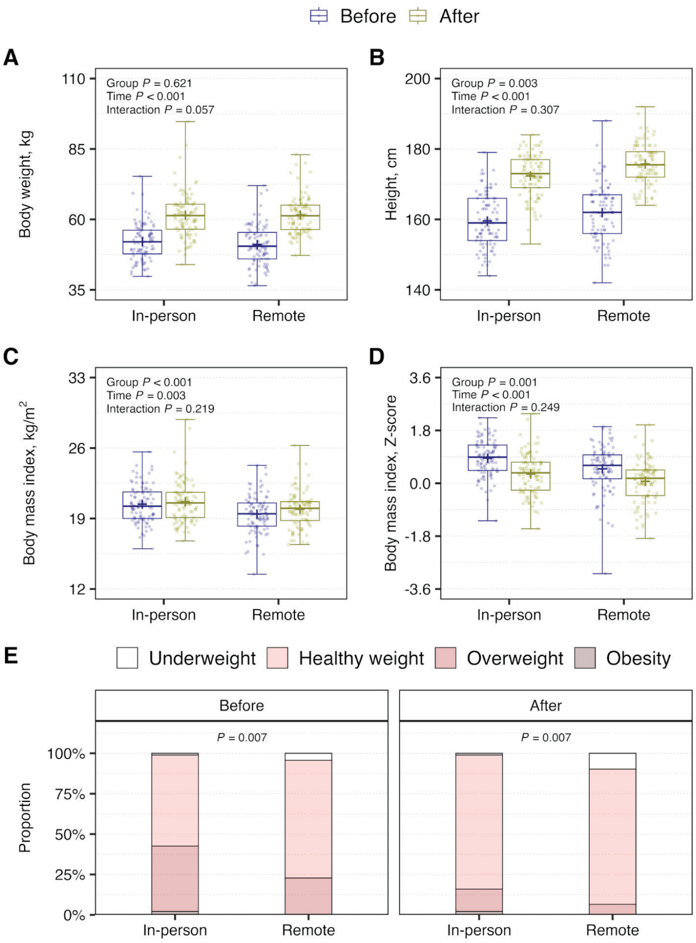

Figure 2. Comparison of anthropometric outcomes before and after two years in male adolescents exposed (remote-schooling) or not (in-person-schooling) to the school closure due to the COVID-19 pandemic. In A-D, ANOVA models were fitted including group, time (repeated measures), and their interaction. In A-C, the analyses were conducted using log10-transformed values, but the variables were plotted on their original scale. In E, Fischer's exact test was used at each time point separately. In-person-schooling n = 94; Remote-schooling n = 92.

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The remote-schooling group had higher height and lower BMI compared with the in-person-schooling group (main effect of group; Figure 2B-D). As expected, body weight, height, and BMI changed after two years of growth and development (main effect of time; Figure 2A-D). There were no group-by-time interactions in these outcomes, indicating that the magnitude of the change was not different between groups (Supplementary Table 2). In agreement, the remote-schooling group (versus the in-person-schooling group) had a lower proportion of overweight and obesity at the before time point (22.8% versus 42.6%), and the difference was maintained after two years (6.5% versus 16.0%; Figure 2E).

A statistically significant group-by-time interaction was observed in VO_2max, indicating that the change in VO_2max over two years differed between groups (Figure 3A). Indeed, VO_2max increased only by 2.0 mL/kg/min in the remote-schooling group, compared with 4.5 mL/kg/min in the in-person schooling group (Supplementary Table 2). This indicates that the expected increase in VO_2max in the remote-schooling group was attenuated by 2.5 mL/kg/min (Supplementary Table 2). Post-hoc analyses revealed no difference between groups before, but lower VO_2max in the remote-schooling group after two years (Figure 3A). Statistically significant group-by-time interactions were also observed in 50-m speed, 800-m speed, and sit-ups (Figure 3B-D). Compared with the in-person-schooling group, the increases in the remote-schooling group were attenuated by 0.4 m/s in 50-m speed, 0.8 m/s in 800-m speed, and 4 repetitions in sit-ups (Supplementary Table 2). Again, post-hoc analyses revealed that the difference between groups was manifested only after two years (Figure 3B-D). A statistically significant group-by-time interaction was also observed in the standing long jump, with attenuated increases in the remote-schooling group by 20 cm (Figure 3E and Supplementary Table 2). In this case, however, post-hoc analyses showed differences between groups before, not after, the two years (Figure 3E). Finally, the remote-schooling group performed fewer pull-up repetitions compared with the in-person-schooling group (main effect of group; Figure 3F). Yet both groups showed similar increases after two years (main effect of time; Figure 3F and Supplementary Table 2).

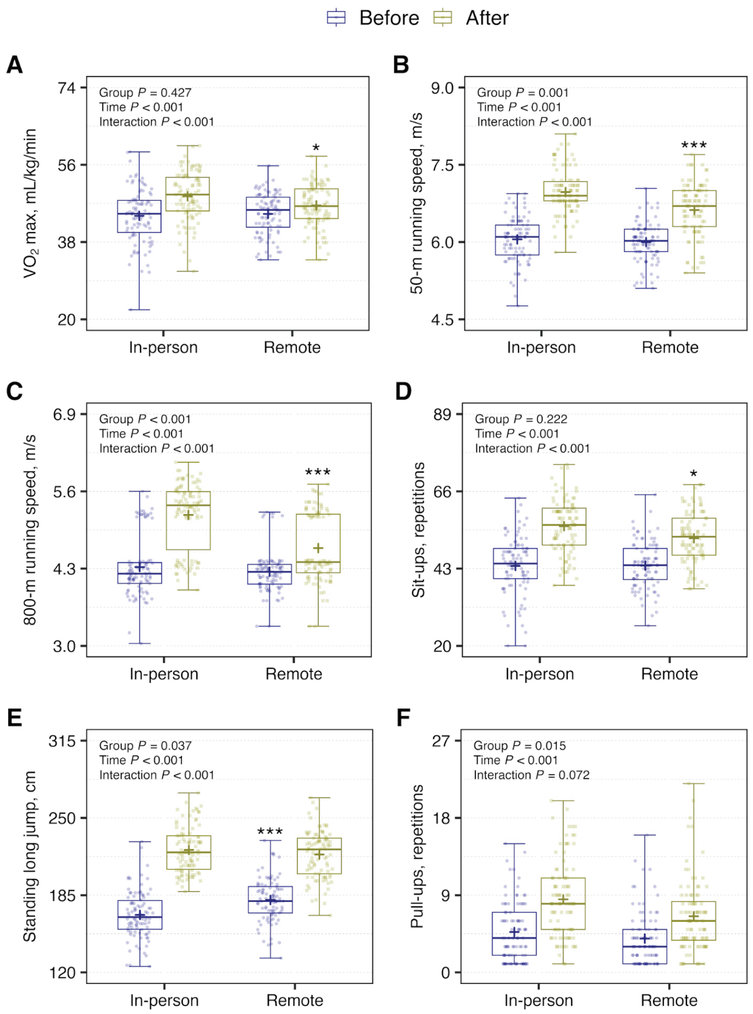

Figure 3. Comparison of cardiorespiratory and muscular fitness outcomes before and after two years in male adolescents exposed (remote-schooling) or not (in-person-schooling) to the school closure due to the COVID-19 pandemic. ANOVA models were fitted including group, time (repeated measures), and their interaction. The analyses were conducted using log10-transformed values, but the variables were plotted on their original scale. *P < 0.05, ***P < 0.001 versus the In-person-schooling group at the same time point for the post-hoc comparison with Bonferroni adjustment. In-person-schooling n = 94; Remote-schooling n = 92.

Discussion

This study aimed to determine the effects of the school closure on the physical fitness of male adolescents attending a private school in Chile. We leveraged data from the COVID-19 pandemic to compare a group of students who were exposed to school closures (remote-schooling) with a control group that attended school normally (in-person-schooling). Both groups were comparable in age and sex and belonged to the same school. Anthropometric outcomes changed similarly in both groups over two years. Nevertheless, the normal gains in cardiorespiratory fitness, speed, and strength were consistently attenuated in the remote-schooling group, suggesting a negative impact of school closures on physical fitness.

The anthropometric changes observed in our participants agree with the expected growth during adolescence. Peak growth in males occurs between 12 and 14 years of age (Chulani & Gordon, 2014), which matches the age of our participants. Both the remote-schooling and in-person-schooling groups showed similar increases in height and weight, indicating that school closure did not affect normal growth.

School closures during the COVID-19 pandemic most likely disrupted children's routines and habits, raising concerns about their health. Similar concerns have been observed during other periods away from school, such as summer holidays, when lower physical activity, reduced cardiorespiratory fitness, and increased adiposity are common (Eglitis et al., 2024). Nevertheless, previous findings during the COVID-19 pandemic have been mixed. Some studies reported increases in the prevalence of overweight and obesity, whereas others did not (Chang et al., 2021; Medrano et al., 2021). Pierce et al. (2023) documented an accelerated rate of BMI increase in early 2020, and a stabilization in 2021, resulting in BMIs above pre-pandemic levels. Basterfield et al. (2024) also reported an initial increase in BMI post-lockdown, followed by stabilization that did not return to pre-pandemic levels. In a previous study with a similar time-matched control design, increases in adiposity were also observed in students from public schools during 2019-2021 (Suárez-Reyes et al., 2024). In contrast, here we did not detect an increase in the prevalence of overweight or obesity in either group. The prevalence remained below 20% in both groups, which is lower than national estimates showing >30% overweight and 16% obesity prevalence in 14-year-old boys in Chile (Junta Nacional de Auxilio Escolar y Becas JUNAEB, 2021, 2022). Notably, those national estimates consider only students attending public schools, whereas our current sample included only students attending a private school. Higher socioeconomic status, often reflected in parental education, has been associated with lower weight gain in children during the school closures. This pattern likely results from better dietary routines, encouragement of physical activity, and limited screen time (Pedersen et al., 2022). Such an advantage may have protected our participants.

Regarding other physical fitness outcomes, both groups showed improvements over the two years (Welde et al., 2020). However, the gains in the remote-schooling group were attenuated across most outcomes. Cardiorespiratory fitness (VO_2max) increased in both groups, but the increase was 2.5 mL/kg/min lower in the remote-schooling than the in-person-schooling group. Cardiorespiratory fitness is a strong predictor of current and future health in youth, and therefore, attenuated increases may indicate less favorable health outcomes. The attenuated increase in the remote-schooling group potentially resulted from reduced opportunities for physical activity due to school closure (Raghuveer et al., 2020). Despite this, note that the median values of both groups remained within healthy fitness ranges for boys aged 12 to 14 years (Lang et al., 2019). Our findings partially contrast with those of Basterfield et al (2024), who reported a decline in cardiorespiratory fitness immediately after lockdown, followed by a recovery and subsequent increase. Whether our remote-schooling group attained the expected cardiorespiratory fitness later after school reopening is unknown.

The remote-schooling group also showed smaller improvements in speed compared with the in-person-schooling group. Speed is related to musculoskeletal and bone health, as well as athletic performance. Our results thus imply that the attenuated gains in speed could impact physical development (Mello et al., 2023).

Muscular strength also showed attenuated increases in the remote-schooling group compared with the in-person-schooling group. Notably, the difference in standing long jump gains may partially reflect differences in performance at the before time point, with the in-person-schooling group starting with a lower performance and thus showing greater improvement. In agreement, Basterfield et al. (2024) reported increases in standing long jump and other strength measures from pre to post pandemic. Nevertheless, they interpreted these gains as evidence that strength was unaffected by the pandemic. Using a time-matched control group, we showed here that the gains were smaller than expected due to normal growth and maturation. Our time-matched design thus allowed us to distinguish the effects of school closure from the normal, expected changes. As muscular strength is linked to multiple health outcomes, the reduced gains in the remote-schooling group could have long-term health implications (Mello et al., 2023). Finally, although the increase in pull-ups was not different between groups, there was a borderline significant interaction consistent with the other muscular strength outcomes.

While this study provides valuable insights, some limitations should be noted. First, although school closure represents a major change in the routine of adolescents, the effects in the remote-schooling group cannot be attributed solely to school closure. Other factors, such as COVID-19 infections and their lingering effects, may have influenced the physical fitness in the remote-schooling group. Second, we did not have measurements of physical activity in any group. Thus, the idea that reduced physical activity levels due to school closure are major determinants of the attenuated fitness gains cannot be confirmed. Note that some studies reported declines in the physical activity levels during the pandemic, whereas others suggested sustained low levels or a partial recovery (Jago et al., 2023; Suárez-Reyes et al., 2024). In any case, reduced opportunities for physical activity due to school closures remain a likely contributor to the attenuated increase in physical fitness. Third, fitness tests were conducted as part of routine school assessments, which may have limited measurement accuracy. Yet school-based testing remains a practical and cost-effective method to monitor youth fitness (Joensuu et al., 2024). Fourth, as the study included a single school, caution is needed when generalizing findings. A major strength of our study was the inclusion of a time-matched control group from the same school. This group allowed us to distinguish the changes due to the school closure from those due to normal growth and development. Finally, we did not adjust for covariates such

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as maturation status, as these data are not routinely collected in school-based assessments. Yet our design, including students from the same school, age, and sex, partially mitigates this issue.

In conclusion, our study suggests that schools play a key role in supporting the development of physical fitness during adolescence. The students from a high socioeconomic background showed overall increases in physical fitness. Nevertheless, the effects were attenuated in the group that was exposed to the school closure. These results provide valuable evidence on the role of schools as environments for promoting health beyond academics, even in a socioeconomically advantaged population.

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