Sport Sciences for Health
https://doi.org/10.1007/s11332-024-01238-0

RESEARCH

Longitudinal 5-year tracking of isometric plank test strength in children and adolescents: a pre- and post-COVID-19 social distancing study

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Received: 9 February 2024 / Accepted: 9 July 2024
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Abstract

Purpose To compare the effects of plank strength levels over a 5-year period (2018 vs. 2023) considering the impact of the COVID-19 pandemic in children and adolescents.

Methods This is a retrospective longitudinal case study with a quantitative approach involving schoolchildren from a school located in South Brazil. The initial sample consisted of 221 students (58.8% boys) aged 6–11 years evaluated in 2018 (baseline). The same group of students was reevaluated in 2023 (follow-up) when they were aged 11–16 years. The assessment of isometric strength in the plank test was conducted by adapting the "core" strength test. The test was performed twice within the same session, and the best measurement was recorded. In addition, 7 days later, a retest was conducted. The abdominal resistance strength was evaluated through the sit-up test, according to the protocol of Projeto Esporte Brasil.

Results Regarding the results of the pre-pandemic (baseline) compared to the post-pandemic (follow-up) in girls, a significant negative effect over the 5-year period was observed in the comparison of raw values for isometric strength in the plank test's first three measurements at baseline, compared to the follow-up. Similar 5-year negative effects were observed in boys as in girls, both in the raw values and in the age-adjusted values, where no significant differences were found.

Conclusion Isometric strength levels on the plank test remained stable over the 5-year period, despite the impact of the COVID-19 pandemic, demonstrating consistent core strength in schoolchildren.

Keywords Core stability · Postural balance · Children · Adolescents

Introduction

Physical fitness (PF) is a powerful health evaluation method for children and adolescents. In addition, PF plays a crucial role in monitoring health and physical performance over time, considering that it is an efficient and low-cost strategy for tracking health and quality of life before and after a global matter such as COVID-19 pandemic [1–14].

The COVID-19 pandemic in 2020 significantly negatively impacted the health, physical fitness and physical activity levels of the general population [1–14]. As we approach 2023, it has become essential to assess the physical fitness of children and adolescents to monitor their musculoskeletal health and physical performance. This monitoring is crucial for planning interventions that aim to mitigate the negative effects of the pandemic, such as low levels of cardiometabolic health and musculoskeletal strength in this age group [11, 13–18].

Another important point of the present proposal concerns controversial results comparing muscular strength in children and adolescents before and after the COVID-19 pandemic. For example, in a study, absolute strength, as indicated by the medicine ball push, was significantly higher after COVID-19 than in previous years [19]. Other evidence shows that upper limb strength remained steady before and after the restrictions. Specifically, for boys of all ages, there was a reduction in lower limb strength and speed-agility but not in upper limb strength [20]. There was no recurrent trend for girls of all ages, while for 6–8 girls, there was a

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Published online: 23 July 2024

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reduction only in strength-speed-agility, while for 9–11 girls, there was a reduction in lower limb strength and strength-speed-agility [20]. Several studies present divergent results, but the prevailing perspective suggests that general physical fitness levels tend to decrease after implementing COVID-19 social distancing measures [21–23]. Therefore, some studies suggest that children with higher levels of physical fitness before the pandemic experienced better protection during the post-pandemic period regarding their general health [6, 13].

In this context, core and abdominal strength are crucial for jumping, running, and balancing activities, particularly in children and adolescents' health-related physical activity habits or those engaged in sports requiring rapid and robust movements [17, 24, 25]. The commonly used sit-up abdominal test to assess strength and endurance in children may not be suitable for those with low fitness levels or reduced motor ability [17, 26]. Moreover, children with conditions such as overweight, obesity, or limited flexibility may face difficulty performing the sit-up test effectively [24]. To address these issues, the abdominal isometric strength test in a "plank" position has emerged as a promising alternative [17, 27–30]. This test involves maintaining an isometric contraction of the core and hip muscles while supporting the body on palms (or elbows) and feet. It could serve as a preparatory evaluation for children transitioning to early elementary school, especially if they are unfamiliar with traditional sit-up tests [17]. Previous studies have shown that the plank test is reliable and reproducible, and core isometric strength correlates with dynamic abdominal strength and overall physical fitness [17, 27–30].

However, there is still limited evidence on the longitudinal measurement of the plank test in children in transition to adolescence considering possible longitudinal associations and impacts from the COVID-19 pandemic period [6, 17, 31], particularly in comparing and associating isometric strength levels before and after the pandemic to other physical capacities, despite the existence of a large body of evidence on physical fitness in the literature [6, 13, 14, 16–18, 32–34]. Considering the present perspectives, this study aims to compare the effects of plank strength levels over a 5-year period (2018 vs. 2023) considering the impact of the COVID-19 pandemic in children and adolescents.

Methods

Design and participant selection procedures

This is a retrospective longitudinal case study that employed a quantitative approach. The initial sample consisted of 221 students (58.8% boys) aged 6–11 years evaluated in 2018 (baseline). The same group of 221 students was reevaluated in 2023 (follow-up) when they were aged 11 to 16 years.

The G*Power software [35] was used to estimate the sample size for this study, which was determined based on the statistical power required for the most complex test used in 2023, which involved multiple and generalized linear regression analysis with five independent factors. The desired test power was set at 80%, with a 5% error margin and an average force relationship (r2) ranging from 0.40 to 0.50. The minimum number of participants resulted in at least 200 individuals, and an additional 10% margin was added to account for potential missing data [17].

The participants were intentionally selected to align with the objectives of the present study. The research included a total of 10 classes, with two classes per grade level. In 2018, all students were invited to take part, whereas, in 2023, only those children who had participated in the initial assessments were invited. The baseline assessment in 2018 involved students from first to fifth grade prior to the COVID-19 pandemic, while the follow-up evaluation in 2023 included students from fourth to tenth grade after the pandemic [17].

The schoolchildren were selected from a school located in the South of Santa Catarina—Brazil. The aim of this approach was to offer an alternative assessment method for the school's physical education teacher, who wanted to assess the strength of the children using the plank test instead of the sit-up abdominal test. The children were motivated to ascertain if their physical fitness levels in the plank test had improved over time. At the conclusion of the evaluations, reports regarding the study were provided to the schoolchildren's legal guardians.

Ethical procedures

The study was conducted with authorization from the participating institution, and informed consent was obtained from parents and guardians. The study was conducted with permission from the participating institution and with informed and clarified consent from parents and guardians. Children also provided voluntary agreement by reading and signing a research assent form. The study received approval from the national ethics and research committee (CONEP) in accordance with the opinion issued by Centro Universitário Estácio de Sá—São José—SC (CAAE: 25315518.4.0000.5357; Opinion number: 3.758.311). All guidelines for research involving human participants were strictly followed, adhering to the principles of the Helsinki Declaration [36]. In addition, the first study published, carried out before the pandemic COVID-19 validated the plank test with a cross-sectional design regarding correlations and reliability to measure trunk muscular strength according to sit-up test mathematical measures [17].

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Instruments and measurement procedures

Only students who participated in the 2018 data collection were invited to take part in the present research. To minimize bias, the evaluations made in 2023 were conducted by the same evaluators who administered the plank test in 2018 (professionals with 10 years of experience) and two external evaluators (PhD holders with 15 years of experience) [17]. The best and most consistent measurements from the two evaluations were recorded, considering the external evaluators' judgment. In addition, a third evaluator reviewed the 2023 measurements to identify any possible inconsistencies.

The study implemented careful measures to ensure rigorous data collection and maintain a coherent approach. Both trained evaluators underwent extensive training and standardization before conducting the tests. This training encompassed proper measurement techniques, appropriate participant interaction, and consistent data recording methods. In addition, the evaluators practiced test administration on a pilot group of participants not included in the main sample. This allowed them to become familiar with the equipment, address logistical issues, and refine their measurement techniques for improved accuracy and consistency. To minimize potential biases, the evaluators performed blind testing during the measurements. They were unaware of participants' previous results, ensuring that any influence based on pre-existing information was avoided.

Randomization was implemented to further enhance the objectivity of the study. The evaluators followed a random order while conducting the tests for each participant, ensuring a balanced distribution of variations in results over time or due to external factors. To uphold data integrity, the evaluators regularly cross-checked their records to identify any discrepancies in the collected data. They reviewed the measurement together to reach a consensus if any discrepancies were found.

In addition, the evaluators conducted periodic meetings to discuss their measurement techniques and offer constructive feedback to one another. This ongoing feedback and discussion process played a crucial role in maintaining consistency and addressing any doubts or issues that arose during the study. Throughout the data collection period, the evaluators continually monitored their own accuracy and adherence to the established protocol, ensuring vigilance and consistency in their approaches.

Furthermore, in order to minimize bias, not only were the evaluators blinded, but the study may have also been blinded for the participants. This double-blinding approach reduced the likelihood of bias in result interpretation. In other words, the database from 2018 was not disclosed to evaluators and participants in 2023 before the study's conclusion.

By incorporating these meticulous measures, the research team aimed to maintain coherence in the study, avoid contradictions and repetitions, and ensure the robustness of the collected data and the validity of the research outcomes.

Baseline: pre-pandemic variable evaluations (2018)

Plank isometric test The assessment of isometric strength in the plank test was conducted by adapting the core strength test [17, 37]. Modifications in the test were made to facilitate the evaluation of the children, as the original version targeted adults. Figure 1 illustrates the initial position of the test.

The evaluations followed the protocol outlined by Lemes et al., [17]. Participants positioned themselves with their palms resting on a mat on the floor or on a clean surface. The wrists were flexed at 90 degrees, elbows extended, and shoulders flexed at 90 degrees, with the spinal column, hip, knees, and ankles joints erect, the soles of the feet and toes touching the floor, and the anterior region of the chest contracted. The hip, hip joint, and knees were suspended and straight. The students' trunks were raised off the floor, without lifting the hip region, in a prone position, keeping the body static for as long as possible or until reaching a maximum time of 150 s (2 min and 30 s). The test time was recorded in seconds from the moment the subject assumed this position, and the test concluded when the individual gave up, touched the floor with a body part other than the hands and the soles of the feet, or when the position was compromised. At this point, the timer was stopped [17].

The test was performed twice within the same session, and the best measurement was recorded. In addition, a retest was conducted 7 days later. Two physical education teachers with 5 years of professional experience conducted these procedures, with one assisting the other in evaluating 4 participants each time the test was administered [17]. It is important to reinforce that, according to previous research [17, 38], the isometric plank test is reliable for measuring core and abdominal strength in schoolchildren during the

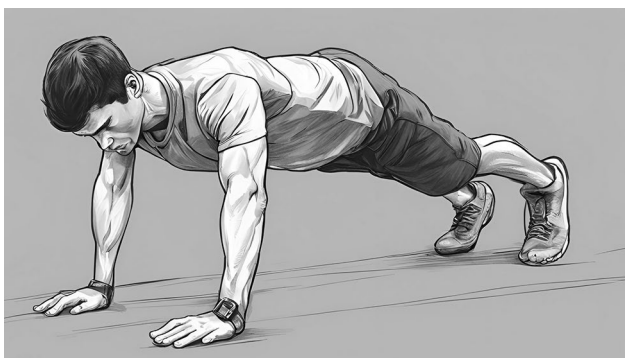


Fig. 1 The plank isometric strength test. Created using DALL.E-2 artificial intelligence software

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transition to adolescence, both before and after the COVID-19 pandemic, with reliable results for boys and girls [17, 38].

Follow-up: post-pandemic evaluations (2023)

During this evaluation period, only the plank test was conducted as the school faced limitations in physical and material resources to administer other tests. The school's gymnasium was under renovation, and the number of students increased by 30% compared to 2018. It is worth mentioning that this school is located in a vulnerable and low-income area [6, 11, 13, 16, 17]. The plank test is a measure created and adapted in the context of Brazilian physical education to address such demand [17].

Statistical analysis

The Kolmogorov–Smirnov test was used to test normality according to visual inspection and box plot ($p > 0.450$ for all variables). Differences between genders were determined through the independent *T* Test with bootstrapping and a 95% confidence interval (95% CI) for 1000 retests, due to the need for statistical robustness.

Each variable underwent a second version through statistical conversion into adjusted *z*-scores. Correlation coefficients (*r*) were then calculated to determine the strength and direction of the retrospective longitudinal effects. Two analyses were conducted: "Crude–data" which represents simple associations without considering other factors, and "Age Adjusted *z*-score–data" which controls for age differences among participants to provide more accurate correlations.

Gender differences, confidence intervals, and delta effects for all data adjusted for age were also presented by means of *z*-scores. Subsequently, we conducted a longitudinal comparison for plank test data, using the crude values of the three measures taken before the pandemic (test 1, 2, and the mean of these tests), and compared them to the plank test value in 2023. This analysis was performed for age-adjusted *z*-scores for each gender, and comparisons were also made for the crude data. Graphical analysis was employed for longitudinal data, and the application of dependent *T*-tests considered the delta effects. All analyses were performed using SPSS software (version 22.0) with a significance level of 5%.

Results

Table 1 presents the characteristics of the sample and the comparison between the genders. The mean age for girls was significantly higher compared to boys. The plank tests showed significant differences only in the follow-up assessment, where boys demonstrated higher values than girls.

Figure 2 and Table 2 provide a comprehensive overview of the plank test results for both girls and boys, comparing assessments conducted in 2018 (baseline) and 2023 (follow-up). The table includes crude values, age-adjusted *z*-scores, means, standard errors, and 95% confidence intervals for each measurement. No difference was found

Table 1 Descriptive characteristics of the sample and comparison by gender

Baseline variables (2018)	Descriptive					Comparison by gender				
		Mean	SE	95% CI		*T*-test	*D*	*p*	95% CI	
				Lower	Upper				Lower	Upper
Age (years)	Girls	9.14	0.15	8.84	9.43	**− 2.43**	**− 0.52**	**0.013**	**− 0.92**	**− 0.11**
	Boys	8.62	0.14	8.33	8.88					
Plank test 1 (s)	Girls	79.64	4.25	71.96	88.84	1.16	7.20	0.225	− 4.39	18.74
	Boys	86.84	4.10	79.04	95.02					
Plank test 2 (s)	Girls	87.42	3.96	79.90	95.68	0.51	3.00	0.571	− 8.41	14.29
	Boys	90.42	3.98	82.58	98.04					
Mean plank test (s)	Girls	83.53	3.87	76.32	91.70	0.88	5.10	0.357	− 6.34	15.80
	Boys	88.63	3.85	81.31	96.13					
Post pandemic (2023)										
Age (years)	Girls	14.14	0.15	13.84	14.43	**− 2.43**	**− 0.52**	**0.013**	**− 0.92**	**− 0.11**
	Boys	13.62	0.14	13.33	13.88					
Plank test (s)	Girls	56.77	2.21	52.49	61.17	**2.47**	**7.43**	**0.013**	**1.46**	**13.06**
	Boys	64.20	1.95	60.57	68.12					

SE Standard error of average, *95% CI* Confidence interval for 95% probability in a bootstrapping for 1000 retests, *D* Delta effect size between genders, *p* Significance level. Bold represents significant differences $p < 0.05$

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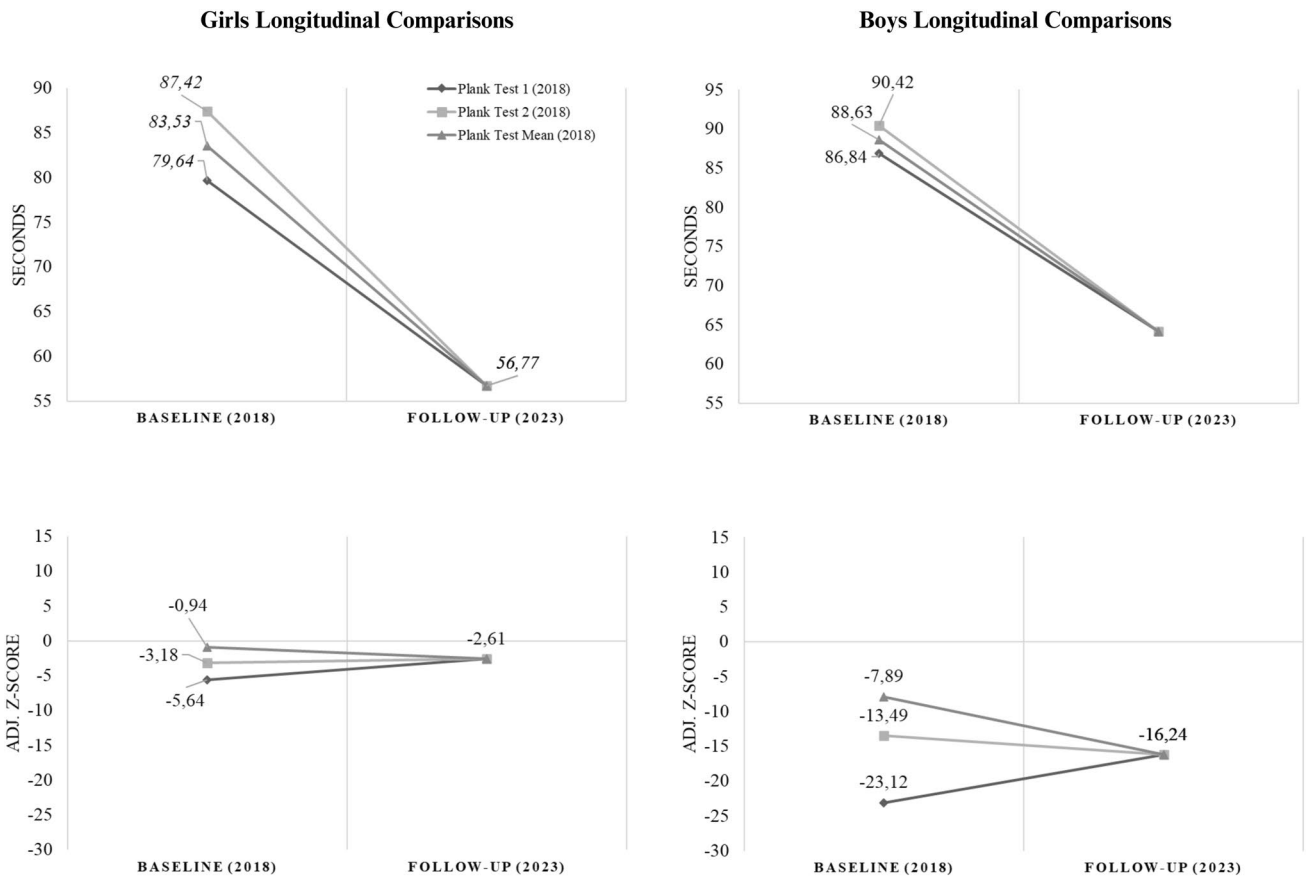


Fig. 2 The effects of pandemic time on plank strength levels over a 5-year period, crude and adjusted by age *z*-score in girls and boys

between the genders regarding the mean variability of the assessments at baseline (Test 1, Test 2, and the mean) and follow-up when considering the age adjustment in *z*-scores (*p* values ranging from 0.886 to 0.956), corroborating the differences between age for girls and boys in crude values (Table 1).

Regarding the results of the pre-pandemic (baseline) compared to the post-pandemic (follow-up) in girls, a significant negative effect over the 5-year period was observed in the comparison of raw values for isometric strength in the plank test's first three measurements at baseline, compared to the follow-up. These comparisons showed large yet significant negative delta effects, for example, (D-95% CI − 30.55 to − 15.19 and − 38.17 to − 23.13; p = 0.001). However, when considering age-adjusted *z*-scores, no significant differences were observed between the baseline and follow-up assessments (D-95% CI − 96.36–90.30 and − 163.21–162.07; *p* value > 0.949).

Similar 5-year negative effects were observed in boys as those seen in girls, both in the raw values, for example, (D-95% CI − 30.66 to − 14.62 and − 34.61 to − 17.83; *p* = 0.001), and in the age-adjusted values, where no significant differences were found, for example, (D-95% CI − 68.60–82.36 and − 128.21–122.73; *p* = 0.856).

Discussion

The present study's main results indicated no significant differences in the mean variability between baseline (pre-pandemic) and follow-up (post-pandemic) in age-adjusted *z*-scores on the isometric core strength in the plank test. This suggests that the performance on the plank test remained relatively stable over the 5-year period, even after the impact of the pandemic.

Our findings present different results from what was hypothetically expected regarding the negative effects of the pandemic on children and adolescents. In general, studies suggest that various physical fitness components tend to be reduced in post-pandemic times, but there is a divergence in strength results, with some children increasing and others decreasing it [6, 8, 13, 21–23, 39, 40].

To add further complexity to the research results on the muscular strength of children and adolescents during

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Table 2 The delta effects of pandemic time in plank strength levels over a 5-year period, crude and adjusted by age *z*-score in girls and boys

	Descriptive						
	Age-adjusted *z*-score	Mean	SE	95% CI Lower	95% CI Upper		
Girls	Plank test 1	− 5.64	96.63	− 198.02	184.46		
	Plank test 2	− 3.18	98.12	− 190.24	187.26		
	Plank mean	− 0.94	98.88	− 194.21	197.96		
	Plank test 2023	− 2.61	100.50	− 200.77	195.18		
Boys	Plank test 1	− 23,12	76,70	− 174.89	129.75		
	Plank test 2	− 13,49	77,76	− 163.42	138.73		
	Plank mean	− 7,89	79,57	− 161.26	149.65		
	Plank test 2023	− 16,24	79,27	− 168.70	144.23		
Gender comparison	Age-adjusted *z*-score	*D*-mean	*D*-SE	*D*-95% CI Lower	*D*-95% CI Upper	Eta	*p*
	Plank test 1	17.48	19.93	− 23.13	54.71	0.01	0.886
	Plank test 2	10.31	20.37	− 26.82	48.53	0.01	0.934
	Plank mean	6.95	19.32	− 32.95	48.31	0.01	0.956
	Plank test 2023	13.63	21.23	− 32.08	50.95	0.01	0.912
Baseline x follow-up comparisons							
Girls	Crude values (s)	*D*-mean	*D*-SE	*D*-95% CI Lower	*D*-95% CI Upper	*T*-test	*p*
	Plank test 1 (2018)–(2023)	22.87	3.87	15.19	30.55	5.92	0.001
	Plank test 2 (2018)–(2023)	30.65	3.78	23.13	38.17	8.10	0.001
	Plank mean (2018)–(2023)	26.76	3.56	19.69	33.83	7.52	0.001
Boys	Plank test 1 (2018)–(2023)	22.64	4.05	14.62	30.66	5.59	0.001
	Plank test 2 (2018)–(2023)	26.22	4.24	17.83	34.61	6.18	0.001
	Plank mean (2018)–(2023)	24.43	3.97	16.58	32.28	6.16	0.001
Girls	Age-adjusted *z*-score	*D*-mean	*D*-SE	*D*-95% CI Lower	*D*-95% CI Upper	*T*-test	*p*
	Plank test 1 (2018)–(2023)	− 3.03	46.98	− 96.36	90.30	0.07	0.949
	Plank test 2 (2018)–(2023)	− 0.57	81.87	− 163.21	162.07	0.01	0.994
	Plank mean (2018)–(2023)	1.67	60.96	− 119.44	122.78	0.03	0.978
Boys	Plank test 1 (2018)–(2023)	− 6.88	38.15	− 82.36	68.60	0.18	0.857
	Plank test 2 (2018)–(2023)	2.74	63.42	− 122.73	128.21	0.04	0.966
	Plank mean (2018)–(2023)	8.34	47.47	− 85.57	102.26	0.18	0.861

SE Standard error, *95% CI* Confidence interval for 95% of probability in a bootstrapping for 1000 retests, *D* Delta effect size, *p* Significance level

the transition from pre- to post-pandemic of COVID-19, significant negative effects were observed in the crude values of isometric strength in both groups of girls and boys over the 5 years, indicating a decline in performance on strength tests during this period. In the present sample, the negative effects were not statistically significant for both groups, boys and girls, when adjusted to age across the time. The divergences in the present studies from other longitudinal data could be due to the fact that other studies did not account for participants' age differences [6, 8, 13, 21–23, 39–41].

This finding suggests that the reduction in isometric strength performance over the 5 years is not only a reflection of the participants' aging but possibly influenced by other factors. The lack of significant differences in the variability of the plank test before and after the pandemic suggests that this component of physical fitness may have remained relatively stable, even in the face of disruptive events like the COVID-19 pandemic, which was also indicated by the literature [41].

From this body of evidence, we understand that lifestyle, social aspects, age, and gender have a higher impact on the strength of children over time is diverse [6, 8, 13, 21–23, 39–41]. These include the variability in pandemic impact across different communities and regions, affected by factors such as lockdown measures, access to online education and physical activities, socioeconomic status, and healthcare infrastructure [6, 16, 18, 41, 42]. Psychological effects, such as stress, anxiety, and depression, can impact motivation and participation in physical activities, affecting muscular

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strength development [39, 43–45]. Lifestyle changes, including increased sedentary behaviors and altered eating habits, also affect physical fitness outcomes [6, 18, 46]. Reduced physical activity opportunities due to restrictions on outdoor activities and the closure of schools during the pandemic may have hindered muscular strength development [11–13]. In addition, challenges in online learning could have led to decreased structured physical activity sessions and limited guidance on exercise techniques [13].

Several aspects may be related to the present results. Still, we can affirm that children and adolescents from this population have remote physical education programs for physical fitness improvement focused on the stay-at-home model [6, 11–13, 16, 17, 38, 47]. This kind of exercise can help the participants of the present study to maintain the strength isometric plank test stable [6, 12–14].

The present results can be used mainly to plan a complex view for multicomponent school physical education interventions based on health promotion. This curricular component plays a crucial role in students' physical and cognitive development. It may have contributed to the abovementioned aspects, such as stability in plank test performance over time and a reduction in negative effects on isometric strength. This is demonstrated in previous research on physical fitness and health conducted in the southern region of Brazil, closely matching the participants of the present study [6, 11–14, 16, 17, 47].

These perspectives emphasize the crucial role of school physical education in safeguarding bodily health through physical activity, increased strength, and overall fitness, even during the pandemic [2, 4, 48, 49]. The mechanisms supporting physical fitness improvements, including isometric strength measured by the plank test, encompass promoting regular physical activity, developing motor skills, encouraging home-based exercise, focusing on health and a positive mental lifestyle, and adopting a comprehensive approach tailored to individual needs [2, 4, 6, 38, 48, 49]. These factors have contributed to maintaining performance levels and mitigating the negative effects of declining isometric strength, underscoring the importance of school physical education in nurturing students' physical well-being [6, 38].

Overall, the present study highlights the importance of assessing physical fitness and considering age-related factors when interpreting results over time. The plank test proved to be a valuable tool for determining isometric strength, contributing valuable visions into children's physical development over several years. Further research may delve deeper into understanding the factors influencing these changes and their implications for promoting overall physical well-being in children [2, 4, 6, 38, 48, 49].

In this sense, the strength of present research is that long-term studies are crucial to understanding the lasting effects of the pandemic on muscular strength, as individual differences in genetics, physiology, and psychology can further influence the outcomes [1, 50–52]. Overall, the complexity of these factors requires comprehensive and longitudinal research designs to untangle and comprehend their combined effects on children's and adolescents' muscular strength, as made in the present proposal. The study highlights the potential protective role of well-implemented school physical education based on health promotion, which may have contributed to the stability in physical performance [6, 12–14].

Furthermore, the study may have some limitations, such as the sample size, the specific methodology used to assess isometric strength, and other uncontrolled variables that may have influenced the results (extracurricular activities in the field of sports, the habits of the sample in terms of physical activity, as well as sedentary activities and eating habits). However, it is important to point out that in a Brazilian context characterized by social vulnerability independently of the Pandemic factor, it is not possible to control all intervening factors in research [53]. Even though complete control is not achievable, it remains crucial to prioritize research efforts that can be carried out pedagogically, clinically, and educationally to support the health of children and adolescents [53]. Some caution is warranted in interpreting the pandemic's direct impact on physical performance, as the analysis focused on understanding changes over time, with the pandemic period as one of the assessment points. Future research could further explore the pandemic's specific effects on physical performance by incorporating pre-pandemic baseline assessments and controlling for other potential variables. Overall, the study underscores the importance of physical education in supporting students' physical development and well-being during challenging times like the COVID-19 pandemic.

Conclusions

The isometric strength levels on the plank test remained stable over the 5-year period, despite the impact of the COVID-19 pandemic, demonstrating consistent core strength in schoolchildren. In addition, a decline in crude values of isometric muscular strength was observed in both boys and girls over the 5-year period, including during the pandemic, but this decline was not statistically significant when adjusted for age, differing from some other longitudinal studies.

From the present study findings, four groups of practical applications can be suggested: (1) incorporating the plank test into school physical education curricula: this ensures that students regularly engage in core strength assessment. By performing the test periodically, educators

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can track individual progress and identify any decline in core strength. Teachers can use the test results to provide personalized feedback to students. Targeted exercises can be recommended to improve performance for those with weaker core muscles. (2) Including the plank test as a specific exercise within core strength training programs is crucial. Educators and fitness professionals can guide students on the proper form and duration for the plank test. Beyond the standard PLANK, variations (such as side planks or dynamic planks) can be introduced to challenge different muscle groups. Progressive overload—gradually increasing the difficulty—ensures continuous improvement. (3) Raising awareness among parents and caregivers about core strength development: they can encourage activities that engage core muscles, both inside and outside of school. Promoting overall physical activity, including aerobic exercises and flexibility training, complements core strength work. Activities such as swimming, dancing, or climbing also engage the core. (4) Incorporating core strength assessment into regular check-ups: health professionals can detect weaknesses or imbalances early. In addition, they can educate families about the significance of core strength for posture, injury prevention, and overall well-being.

Author contributions VBL and CB wrote the main manuscript text. VBL prepared the figures. All the authors reviewed the manuscript.

Funding No funding was received for conducting this study.

Data availability No datasets were generated or analysed during the current study.

Declarations

Conflict of interest The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. The authors have no relevant financial or non-financial interests to disclose.

Ethical approval and Informed consent The study received approval from the national ethics and research committee (CONEP) in accordance with the opinion issued by Centro Universitário Estácio de Sá – São José - SC (CAAE: 25315518.4.0000.5357; Opinion number: 3.758.311). The study was conducted with permission from the participating institution and with informed and clarified consent from parents and guardians. Children also provided voluntary agreement by reading and signing a research assent form.

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