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One-Year Post COVID-19 Change in Physical Fitness of Primary School Children and Its Individual-Level Predictors

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Abstract

Objectives. The study aimed to evaluate physical fitness and its dynamics in a year among primary school children aged 7 to 10 years old concerning the child's individual factors (health-related: physical activity, sedentary behaviour; and psychosocial: physical activity enjoyment).

Materials and methods. The study involved a sample consisting of 902 1st-3rd grade students (49% of boys and 51% of girls), who participated in physical fitness testing at baseline and follow-up in a year. Additionally, questionnaire-based data were collected from students and parents. Physical fitness was evaluated by administering eight out of nine tests from a 9-item test battery developed by Fjørtoft et al. (2011). The participants' height and weight were measured using a mechanical stadiometer platform (Seca 274, Hamburg, Germany; TEM50.01%) and a portable electronic scale — a TANITA BC 420 SMA (Tanita Europe BV, Amsterdam, The Netherlands), respectively. Physical activity, sedentary behaviour, participation in sports, physical activity enjoyment were evaluated by children and parents at different time points.

Results. The results indicated that physical fitness had improved from baseline to follow-up, with some exceptions for particular tests and genders. Vigorous physical activity at Time 1 predicted better hand muscle strength (Std $\beta = 0.18$) and agility (Std $\beta = -0.12$) at Time 2. The findings showed that participation in sports at Time 1 was also predictive of improved agility (Std $\beta = 0.15$). Moderate to vigorous physical activity at Time 1 predicted enhanced speed at Time 2 (Std $\beta = -0.16$). The motivation for physical activity at Time 2 was found to be related to improvements in agility (Std $\beta = -0.18$) and speed (Std $\beta = -0.30$), while there was a decline in hand muscle strength (Std $\beta = -0.11$). Altogether, predictors were able to significantly explain 10 percent of agility and 13 percent of speed test results.

Conclusions. As children grow and develop, their physical fitness levels tend to change in response to various factors including different physical activity indicators, as well as motivation for engaging in physical activity.

Keywords: physical fitness, primary school children, longitudinal study, motor fitness, musculoskeletal fitness.

Introduction

The year 2020 was marked by the global COVID-19 pandemic followed by confinement and home-schooling for almost a year. The pandemic had an impact on many educational and health as well as health behavior outcomes of schoolchildren including lower physical activity at physical education (PE) lessons during distance learning (Roe et al., 2021), lower levels of physical activity (Caputo & Reichert, 2020), more time spent passively (Roe et al., 2021; Rossi et al., 2021), limited or none participation in after school organized sports (Calcaterra et al., 2022). Meanwhile, physical activity in childhood is reported to have a significant accumulative impact on future health, particularly physical fitness (Telama et al., 2014). Moreover, studies report increased body mass index as a negative consequence of the pandemic (Jarnig et al., 2021; Tsoukos & Bogdanis, 2021) as another health trigger. In Lithuania, schools closed on 16th March 2020 and opened on 15th June 2020. Then, after the incidents of COVID-19 increased dramatically again, schools closed in 14th December 2020. Primary school children returned to school and normal physical education on 15th March 2021. It became crucial to evaluate children's after-pandemic physical fitness, given it is a determinant of future health.

Organizations like the United States Department of Health and Human Services ([USDHHS], 2018) and, the National Center for Chronic Disease Prevention and

Health Promotion (1996) called for regular youth fitness testing. The assessment of physical fitness brings vital information for individual healthcare and public health to improve health (Kolimechkov, 2017; Ortega et al., 2015), especially for primary prevention of cardiovascular disease (Ruiz et al., 2016). Regular monitoring of physical fitness is recommended by The American Heart Association (AHA). Following these recommendations becomes specifically important in times of crisis like COVID-19 when regular education experiences drastic changes and normal PE is not available in many cases.

Physical fitness is defined as a state of good health that allows one to perform daily activities vigorously and also helps to reduce the risk of chronic diseases and premature death (Castro-Piñero et al. 2019). The main components of physical fitness are cardiorespiratory fitness, musculoskeletal fitness, and motor fitness. Physical fitness plays a key role in a child's sustainable growth and developmental process (Zhou et al., 2014). Low physical fitness is an important risk factor for cardiovascular disease, type 2 diabetes, and mortality (Faselis et al., 2012; Kokkinos et al., 2012; Timpka et al., 2014). Low cardiorespiratory fitness is associated with a risk of mental and physical health (Ortega et al., 2008). Although morbidity usually comes to manifestation in midlife, the basis for disease develops progressively over time with some signs appearing as early as childhood (Peralta-Huertas et al., 2008) or adolescence (Högström et al., 2016). Also, higher physical fitness, particularly motor fitness is associated with improved children's cognitive abilities and academic achievements (Batez et al., 2021; London & Castrechini, 2011; Moradi et al., 2019; Ruiz-Ariza et al., 2017) as well as better quality of life in childhood (RedondoTébar et al., 2019).

Before the pandemic, physical fitness in school-aged children was constantly declining from decade to decade (Malina, 2007; Olds, Ridley, & Tomkinson, 2007; Venckunas et al, 2017). Reports on secular trends in physical fitness state that cardiorespiratory fitness which is of utmost importance for heart health declined during the last several decades (Venckunas et al., 2017; Fühner et al., 2021) as well as musculoskeletal fitness (Fühner et al., 2021). Some researchers noticed that 7.3% of the decline in cardiorespiratory fitness over 33 years from 1981 stabilized around 2000. However, this is applied only to cardiorespiratory fitness and serves as a general trend, given it was made by summarizing data from 137 countries, and may vary from country to country (Tomkinson et al., 2017). In Lithuania, cardiorespiratory fitness has declined by as much as 50 percent from year 1992 to 2012 among adolescents (Venckunas et al., 2017). This might be related to the population's increasing and earlier onset of health problems in society, and disease-related costs for the health care system.

The complex etiology of physical fitness among other factors like endogenous factors (genes, gender, and maturity), and exogenous ones like health-related behaviors, with children without overweight or obesity and more physically active and eating healthier are more fit than those obese and lacking appropriate dietary patterns as well as physical activity (Cabanas-Sánchez et al., 2018). Studies of physical fitness among young children mostly investigate the predictive value of the latter for different health and academic outcomes. However, evidence for etiology is scarce for young children. Moreover, there is a lack of longitudinal studies including predictors of current physical fitness from different time points.

Thus, physical fitness is affected by multiple factors, and the effect of each could be compensated or amplified in their interplay. Therefore, studies of separate factors do not tackle this interaction. The most proximal factors according to the Ecological approach are individual (intrapersonal) ones (Sallis et al., 2015). Examining the interplay of these factors and identifying the unique significance of each contributing to improvement of physical fitness of primary school children is of utmost importance and will let identify targets for future interventions. Thus, we hypothesize that physical fitness improves after returning to school and normal life after COVID-19 confinement and improvement is significantly associated with physical activity facors.

According to the statements mentioned above, the research aims to estimate physical fitness and its dynamics in a year among primary school children aged 7 to 10 years in relation to the child's individual factors (health-related: physical activity, sedentary behavior; and psychosocial: physical activity enjoyment).

Materials and Methods

Study Participants

This analysis included a sample consisting of 902 students, who participated at both time points and whose additional data from questionnaires were collected. At Time 1 they were 1st to 3rd grade students and at Time 2, they were 2nd to 4th grade students. For each of the tested students data was obtained from one of their parents them filling the questionnaires. Among students, there were 49% of boys and 51% of girls. The majority of parents consisted of mothers (83.2%). Data included 38.8% 7-years-old, 24.8% 8-years-old, 28.6% 9-years-old, 7.8% 10-years-old children at Time 1, and the respective amount of 8, 9, 10, and 11-years-old students at Time 2.

Study Organization

This study was part of a bigger PhD project (KD-19062. 2019), which aimed to represent national indicators of the physical fitness of primary school students. The initial sample of tested students consisted of 2886 students in primary school grades 1 to 4th. However, questionnaires were delivered to the smaller part of students of the initial sample and their parents or guardians. All children had their physical fitness evaluated. At Time 1 parents filled the questionnaires. At Time 2 students were also provided questionnaires to fill out.

Ethics approval for the research was obtained from the Lithuanian Sports University Ethics Committee (No. SMTEK-52). Research-related information was disseminated through the schools' administrations. Parents or legal guardians provided written informed consent and children for their consent were asked verbally. Physical fitness testing is a part of a yearly physical education curriculum and collected indicators are provided to the Lithuanian Healthcare Ministry. Only students who were allowed to attend physical education classes were tested. During the year between tests, all tested students at their school had three physical education lessons per week.Indicate methods and the purpose of their use; research procedures and an algorithm for conducting a pedagogical experiment.

Measures

Physical Fitness

Eight out of nine tests from a 9-item test battery developed by Fjørtoft et al. (2011) and described in detail elsewhere (Fjortoft et al., 2011) were used to evaluate muscular, and motor fitness in primary school students. The test battery included the following tests for musculoskeletal fitness: Standing broad jump (explosive strength), Jumping a distance of 7 m with both feet, Jumping a distance of 7 m on 1 foot (both tests indicate leg muscle strength), Throwing a tennis ball with one hand (arm muscle strength), and Pushing a medicine ball with both hands (upper body muscle power). For motor fitness, the students performed a shuttle run of 10X5 m (agility) and Running 20m as fast as possible (speed) (Fjortoft et al., 2011).

Height was measured to the nearest 0.1 cm using a mechanical stadiometer platform (Seca 274, Hamburg, Germany; TEM50.01%). Body mass was measured to the nearest 0.1 kg using a portable electronic scale—a TANITA BC 420 SMA (Tanita Europe BV, Amsterdam, The Netherlands). Body mass index (BMI) was calculated as mass kg/height $(m)^2$. The International cut-off points for body mass index for overweight and obesity were applied by Cole and colleagues (2000) to differentiate between 1) not overweight and 2) overweight or obese children. The children were clothed in underwear and were barefoot while their anthropometric measurements were taken.

Individual Measures

Physical activity and time spent passive (Time 1). Physical activity and time spent passively by primary school-aged children were assessed by their parents filling out a questionnaire developed by Bacardi-Gascón and colleagues (Bacardi-Gascón et al., 2012). We used four questions assessing time spent passively, in light, moderate, and vigorous physical activities (watching television, going to school, time in the yard, in the park, playing games, etc.). Answers to choose from were as follows: 15 minutes, 30 minutes, 45 minutes, 1 hour, and more than 1 hour. We binarized answers on each item into 1 – less than an hour and 2) more than an hour.

Participation in sports (Time 1) was assessed by the question "Does your child participate in any of these activities during the week?". A list of possible activities was provided (karate, gymnastics, soccer, dance, baseball, swimming, etc.). the answers were dichotomized into 1 (Yes) and 2 (No).

Physical activity (Time 2) was measured by asking students themselves two questions: 1) How many times per week do you play active games, and/or do sports until sweat; 2) How much time do you usually spend each time playing active game and/or doing sports on average? The total score of physical activity in hours was calculated by multiplying the number of days per week with minutes per activity ocation and dividing by 60.

Time spent passive (Time 2) was identified by asking students how much time in hours and minutes they spend watching TV, using a computer, doing homework, reading books, playing table games, and playing with or talking on a smartphone. All the numbers were summed up into total minutes spent passively per day.

Physical activity enjoyment (Time 2). The 16-item PACES (Physical Activity Enjoyment Scale; Moore et al., 2009) questionnaire for students was used to assess the enjoyment of being physically active. Answers were provided on a 5-item Likert scale from 1 – "Definitely no" to 5 – "Definitely yes". The sum of all 16 items was used for calculations. The higher the score the higher the motivation to participate in physical activities. The Cronbach alpha of the scale was 0.867.

Statistical Analysis

Descriptive statistics was employed for the evaluation of means, standard deviation for scale variables, and frequencies for categorical or ordinal variables. Student t criteria were used to identify mean differences among two groups and ANOVA – for more than two groups. A pairwise comparison was performed to identify differences in scale variables between the two time points. The series of hierarchical linear regressions were made to evaluate the unique value of independent variables – covariates and groups of predictors – for dependent variables. Statistical software package SPSS 28 was used for calculations. Results were considered statistically significant when the value was <.05.

Results

Firstly, sample characteristics were analyzed and compared in gender and age groups. Results presented in Table 1.

Descriptive statistics in Table 1 show that there are 7 percent of overweight or obese children. A comparison of results between genders and age groups revealed that older children are overweight or obese more often than their younger counterparts. There is no gender-related prevalence of overweight or obesity. Inactivity, light, and vigorous physical activity at Time 1 were similar between genders and among age groups. Boys and those aged 7 and 9 years old engaged in MVPA at Time 1 more often than girls and those aged 8 and 9 years old. At Time 2 boys displayed higher scores on time spent passively than girls. However, inactivity is similar among different ages primary school students. More than eight out of ten children are engaged in extracurricular sports, with boys and older children engaged more often than girls and younger children. Engagement in MVPA in terms of hours spent in MVPA per week constantly increases with age. Physical activity enjoyment remains the same across genders and age groups.

Results in Table 2 reveal that explosive muscle power (Standing broad jump) constantly increases with age in both boys and girls with a higher magnitude in older age for boys. The older the age the higher the difference in Standing broad jump results in comparison with the previous measurement one year before in boys. However, the increase in girls is not that smoothly rising – the gain between 7 and 8 years and 9 and 10 years is higher than between 8 and 9 years. Similarly, in constantly increasing order changes in leg muscle strength are observed performing Jumping on one foot test in girls for

Table 1. Descriptive statistics and comparisons between age groups and gender

Individual factors	Total	Boys	Girls	7/8 years	8/9 years	9/10 years
Gender						
Boys (% (N))	50.7 (263)					
Girls (% (N))	49.1 (254)					
Age (years; Time 1; mean (SD))						
7	24.2					
8	23.9					
9	23.5					
10	23.1					
11	5.3					
BMI (Time 1; mean (SD))						
Normal	93.0	92.5	93.4	90.4	92.7	93.0
overweight, obese	7.0#	7.5	6.6	9.6	7.3	7.0
Sedentary behavior after school (Time 1; %)						
<1 h/day	11.6	9.0	13.8	9.2	11.5	14.7
>1 h/day	88.4	91.0	86.2	90.8	88.5	85.3
Light PA (Time 1; %)						
<1 h/day	48.1	48.1	48.1	50.8	49.3	47.3
>1 h/day	51.9	51.9	51.9	49.2	50.7	52.7
MVPA (Time 1; %)						
<1 h/day	33.3	26.0	39.4	26.9	40.6	34.0
>1 h/day	66.7*#	74.0	60.6	73.1	59.4	66.0
VPA (Time 1; %)						
<3.5 h/week	73.4	72.5	74.1	79.3	79.9	65.9
>3.5 h/week	26.6	27.5	25.9	20.7	23.1	34.1
Sports (Time 1; %)						
Engaged	86.4*#	90.1	82.6	72.5	73.8	85.8
Not engaged	13.6	9.9.	17.4	27.5	26.2	14.2
Sedentary behavior after school (Time 2; min/day; mean (SD))	394 (175)*	433.94 (172.75)	377.35 (174.73)	393.13 (178.27)	419.80 (179.68)	397.54 (164.79)
MVPA (Time 2; h/week)	6.24 (5.03)#	6.81 (5.54)	5.89 (4.99)	5.45 (4.58)	6.22 (5.27)	6.37 (4.96)
PA enjoyment (Time 2)	68.28 (9.63)	68.19 (9.17)	69.35 (9.20)	69.85 (8.82)	68.72 (9.18)	68.42 (8.75)

Note: BMI – body mass index; PA – physical activity; MVPA – moderate to vigorous physical activity; VPA – vigorous physical activity; * - statistically significant ($p<.05$) difference between genders; # - statistically significant ($p<.05$) difference among ages.

all age transitions and in boys from 8 to 10 years. Jumping on two feet test results increase from 8 to 10, with a higher magnitude between 8 and 9 in both genders. Hand muscle power and upper body muscle power (Tennis ball and Medicine ball, respectively) increase from year to year except for no significant gain in girls in the transition between 9 and 10 years for the Medicine ball test. Agility results in boys increasing across transitions from 8 to 9 years and from 9 to 10 years. There was no significant gain in one year between 7 and 8 years in boys for agility. In girls, agility increases across all age transitions, the highest increase is between ages 9 and 10 years. The speed significantly increases in boys and girls except for the transition in girls from 8 to 9 years.

Results in Table 3 show that among covariates the initial result on the test on Time 1 and age are the strongest predictors of the results a year after. The higher was initial physical fitness the higher it remains after a year passes by. Boys outperformed girls on explosive muscle power (Standing broad jump) until predictors were added, and hand muscle power (Tennis ball, Medicine ball). Leg muscle power (Jumping on one foot and Jumping on two feet), agility (5x10), and speed (20m run) were similar between boys and girls ($p>0.05$). Overweight or obesity predicted lower explosive muscle power, leg muscle power, speed until predictors were added, and hand muscle power (Medicine ball) after predictors were added. Covariates were able to

Table 2. Pairwise comparison of physical fitness indicators in one year

Tests		The transition from 7 to 8 years		The transition from 8 to 9 years		The transition from 9 to 10 years	
		Boys	Girls	Boys	Girls	Boys	Girls
Standing broad jump	Time 1	115.71 (20.23)	103.37 (18.07)	116.03 (24.42)	114.02 (21.12)	128.64 (23.20)	118.17 (18.63)
	Time 2	129.21 (17.84)***	118.61 (16.74)***	132.95 (20.66)***	127.18 (21.41)***	148.43 (24.31)***	137.00 (22.41)***
Jumping on one foot	Time 1	3.62 (0.86)	3.93 (0.95)	3.53 (0.75)	3.69 (0.60)	3.28 (0.51)	3.48 (0.53)
	Time 2	3.43 (0.75)	3.48 (0.61)**	3.19 (0.59)**	3.18 (0.53)***	2.86 (0.55)***	2.96 (0.53)***
Jumping on two feet	Time 1	3.83 (0.95)	4.25 (0.85)	3.80 (0.78)	3.90 (0.67)	3.46 (0.76)	3.71 (0.55)
	Time 2	3.73 (0.85)	3.90 (0.62)	3.32 (0.72)***	3.28 (0.62)***	3.16 (0.72)***	3.15 (0.61)***
Tennis ball	Time 1	10.82 (2.98)	9.66 (4.52)	10.59 (3.95)	9.53 (3.00)	13.96 (5.28)	11.20 (3.67)
	Time 2	15.57 (4.04)***	12.28 (3.77)*	14.50 (4.61)***	14.41 (3.77)***	18.09 (2.86)***	15.66 (2.71)***
Medicine ball	Time 1	2.63 (0.65)	2.26 (0.62)	2.97 (0.86)	2.72 (0.65)	3.65 (0.80)	2.95 (0.63)
	Time 2	4.00 (0.70)***	3.47 (0.60)***	3.87 (0.89)***	3.86 (0.82)***	4.81 (0.92)***	3.99 (0.79)
Shuttle run 5×10	Time 1	23.31 (3.73)	24.60 (2.17)	23.89 (2.22)	23.64 (2.40)	22.85 (3.11)	22.57 (4.27)
	Time 2	22.17 (2.81)	22.82 (2.38)***	21.56 (2.99)***	21.58 (2.39)***	20.24 (2.40)***	21.14 (2.10)*
Shuttle run 20 m	Time 1	5.26 (0.50)	5.60 (0.45)	5.00 (0.80)	4.81 (0.83)	4.60 (0.76)	4.80 (0.46)
	Time 2	4.49 (0.71)***	4.56 (0.50)***	4.54 (0.53)**	4.56 (0.66)	4.12 (0.52)***	4.21 (0.64)***

Note: * - p < 0.05; ** - p < 0.01; *** - p < 0.001.

Table 3. Prediction of physical fitness among primary school children

Individual factors	Standing broad jump	Jumping on one foot	Jumping on two feet	Tennis ball	Medicine ball	Shuttle run 5x10	Shuttle run 20 m
Covariates							
Gender (female)	-0.11*/-0.10	0.03/-0.02	-0.01/0.01	-0.15**/0.18*	-0.18**/-0.18*	-0.02/0.10	0.03/0.06
Age	0.37**/0.22**	-0.33**/-0.32**	-0.41**/-0.33**	0.47**/0.34**	0.42**/0.18*	-0.22**/-0.24**	-0.53**/-0.22*
BMI (overweight, obese)	-0.11*/-0.14*	0.10*/0.07	0.09*/0.10	-0.06/-0.03	0.06/0.14*	-0.02/0.08	0.11*/0.08
Time 1 indicator for the corresponding test	0.39**/0.44**	0.35**/0.34**	0.27**/0.23**	0.28**/0.26**	0.15**/0.18*	0.18**/0.10	0.19**/0.15**
Predictors							
Inactivity (Time 1; >1 h/day)	0.01	0.02	0.01	0.10	0.02	0.24	-0.08
Light PA (Time 1; >1 h/day)	0.05	-0.05	-0.04	-0.003	-0.01	-0.23	0.02
MVPA (Time 1; >1 h/day)	0.02	-0.05	-0.02	0.01	0.08	-0.03	-0.16*
VPA (Time 1; >3.5 h/week)	0.06	-0.01	-0.06	0.18*	0.07	-0.12*	0.002
Sports (Time 1; not engaged)	-0.07	-0.04	0.03	0.06	-0.04	0.15*	0.11
Inactivity (Time 2; h/day)	0.01	0.07	0.01	0.07	0.11	0.80	-0.12
MVPA (Time 2; h/week)	0.09	-0.04	0.001	-0.07	0.09	-0.02	0.21
Motivation	0.07	-0.10	-0.11	0.06	-0.11*	-0.18*	-0.30**
ΔR^2(cov)/ΔR^2 (pred)	0.39***/0.03	0.30***/0.02	0.22***/0.02	0.28***/0.05	0.20***/0.05	0.13***/0.10***	0.16***/0.13**

Note: BMI – body mass index; PA – physical activity; MVPA – moderate to vigorous physical activity; VPA – vigorous physical activity; * - p < 0.05; ** - p < 0.01.

explain from 13 percent (agility) up to 39 percent (explosive muscle power).

Among predictors, vigorous physical activity at Time 1 predicted better performance in hand muscle power and agility at Time 2. Participation in sports at Time 1 also predicted better agility. Moderate to vigorous physical activity predicted better speed at Time 2. Motivation for physical activity at Time 2 is related to better agility and speed and worse hand muscle power. Predictors altogether were able to significantly explain 10 percent of agility and 13 percent of speed test results. Predictors explained 2 to 13 percent of physical fitness depending on the test.

Discussion

This study aimed to identify predictors of after-COVID-19 changes in the physical fitness of primary school children. Firstly, the results revealed that, as supposed in the previous research (Fransen et al., 2014), physical fitness in primary school children improves with age with some stagnation for some physical fitness characteristics at a certain age transition. For instance, the most stagnative transition for boys was the one from 7 to 8 years. In this period explosive muscle power, hand muscle power, and speed improved but leg muscle power and agility showed no significant gain. There might be a premise that for those mostly first-graders their first year at school was not enough time to accumulate the effects of organized sports including school physical education and after-school sports, which children usually begin to practice as they start primary school. However, their natural physical activity deteriorated during the confinement in the previous year. 7-year-old children at baseline had lower VPA at baseline and less time spent in MVPA at follow-up than their older counterparts. Though these results are valid for both genders, still girls were less sedentary than boys at follow-up in this study, which probably contributed to their small improvements in physical fitness at this particular transition from 7 to 8 years. Despite all said above, a general trend observed that children improve their physical abilities one year after returning to school after COVID-19 confinement.

The increased over the year physical fitness discussed above was associated with different physical activity factors at baseline and follow-up. The importance of physical activity was obvious even after controlling for baseline physical fitness results, other sociodemographic characteristics, and body mass index. Namely, children who performed better at agility and muscle power tests had more vigorous physical activity at baseline based on their parents' evaluation. Engagement in sports at baseline was associated with better agility results at follow-up. The MVPA at baseline was related to a better performance in the speed test. Motivation to engage in physical activity at follow-up was related to better agility and speed performance. Physical activity indicators were more prominent in explaining speed and agility (13 and 10 percent, respectively) than other physical fitness qualities.

Other studies also found that children's muscular strength and endurance were associated with their total weekly PA minutes and participation in sports/dance (Chen et al., 2018). The UP&DOWN Study adds that the most active and less sedentary cluster of students has the best physical fitness among other clusters formed from health-related behavior patterns (Cabanas-Sánchez et al., 2018). Moreover, other researchers suggest that not minutes but intensity of physical activity that counts. Each modality of physical activity accumulates into better physical fitness in primary school children, however, results favored more intensive PA. In a similar study in Estonian children, researchers found that VPA at the age of 6 years was positively related to agility, explosive muscle power, and hand muscle strength at 12-month follow-up (Reisberg, Riso, Jürimäe, 2020). So, authors suggest that VPA is crucial for the development of motor fitness and agility in young children (Reisberg, Riso, Jürimäe, 2020), as well as is required in different types of sports and play (Miller et al., 2019). On the other hand, the relationships between sports, play, motivation towards physical activity, and physical fitness are reciprocal (Henning et al., 2022).

The current study did not indicate any impact of sedentary behavior on physical fitness either at baseline or at the follow-up. Meanwhile, other studies show the negative impact of sedentary behavior on upper and lower-body muscular strength (Reisberg, Riso, Jürimäe, 2020). After school, primary school children in our sample are sedentary for about 6.5 hours/day. However, most of them were engaged in afterschool sports (86 percent), and the mean time of engagement in MVPA was close to the recommended norm (6.24 hours/week versus 7 h/week). So, probably these sample characteristics compensated for the negative impact that sedentary behavior has on physical fitness.

There is no available scientific data on changes in primary school children's physical fitness after COVID-19 confinement. The current study is among the first in this area of research. A similar study in Spain, just in a sample of adolescents also found growth in physical fitness (upper body power, strength endurance, cardiovascular fitness, flexibility, and eye-hand coordination). That study also highlighted the importance of after-school sports to compensate for the negative effects of confinement on physical fitness (Carriedo et al., 2022). Physical fitness in French primary school children was measured right before and right after the confinement and showed a drastic decline in performance (Chambonnière et al., 2021). Another study in Greece, among adolescents found that after 5 months long confinement lower-body fitness, was impaired for both genders, but flexibility and upper-body fitness were impaired only in males (Tsoukos & Bogdanis, 2022). The EMOTIKON Project study also revealed that a cohort of third-graders after the confinement had lower physical fitness than is expected for their age (Teich et al., 2023).

The comparison of this data with pre-COVID-19 nationally representative results (Emeljanovas et al., 2020) showed inconsistent trends. Namely, at baseline explosive muscle power and upper body muscle power were lower in the post-COVID-19 sample than in the pre-COVID-19. However, leg muscle power and agility results were better in the after-COVID-19 sample. Pre- and post-COVID-19 studies in China with the same study participants also identified interesting facts. Namely, cardiorespiratory fitness and explosive force (i.e., 50-m sprint) deteriorated during the lockdown. However, muscular strength (i.e., pull-ups) improved. The deterioration was bigger for those adolescents who had greater physical fitness before the lockdown (Zhou et al., 2022).

Moreover, in the current study at follow-up, the results for particular age children were in most cases better than the results of their peers of the same age at baseline. That again confirms that returning to school and having regular physical education as well as after-school sports presumably accelerated the improvement in physical fitness. Systematic review and meta-analysis noticed that both quality and quantity-based physical education interventions contributed to an increase in physical and motor fitness (García-Hermoso et al., 2020). While some other studies add that to achieve significant improvement in physical fitness daily physical education is required (Greier et al., 2020; Erfle & Gamble, 2014). All previously mentioned characteristics of physical fitness are important for children‘s everyday functioning and play (Henning et al., 2022; Sandford et al., 2015), which promotes not only physical but also social and emotional well-being (Bento & Dias, 2017).

Still, covariates explained the higher percent of the variance than physical activity indicators. The baseline result of a particular physical fitness indicator was one of the most prominent predictors at follow-up for the same physical fitness indicator. The baseline result was the most prominent specifically for explosive muscle power. For agility, speed, and hand muscle power age was even more important for improvement. Baseline fitness results serve as a crucial reference point for assessing progress over time. Differences in gender groups were found in explosive muscle power and leg muscle strength results, boys have performed better. Being overweight or obese predicted lower results of explosive muscle power, leg muscle strength, and speed after controlling for the rest covariates.

Absence of overweight is important for a child‘s health (Reilly & Kelly, 2011), life satisfaction (Lopez-Agudo & Marcenaro-Gutierrez, 2021), physical activity (Ortega et al., 2013), and academic performance (Kim & So, 2013). The current study identified 7 percent of overweight or obese primary school children. The prevalence of obesity in Lithuania is lower than in some other countries, however, its numbers have risen recently. Overweight and obesity in this study predicted lower explosive muscle power, leg muscle strength, and speed, but better hand muscle power, while controlling for other study variables. Similarly, another study found that body mass index was positively related to upper-body muscle power and negatively to explosive muscle power (Sacchetti et al., 2012). The study revealed better performance in explosive muscle power, leg muscle power, agility, flexibility, and cardiorespiratory tests for under/normal weight students compared to overweight/ obese ones in the region of Emilia-Romagna region (Russo, 2020). Another research confirmed that body mass index among other body composition indicators affects physical fitness test results (Müller et al., 2022).

Limitations

We did not measure changes in predictors. Physical activity characteristics were measured with different instruments at each time point. Moreover, at Time 1 these characteristics were presented by children‘s parents and at Time 2 by primary school children themselves. Further, despite we did control for some factors looking into the unique impact of our predictors, there might be some other covariates that we have not controlled for like heredity, maturity level, and socioeconomic factors. Even though there was not the aim of the current study, it would be more valuable if we had measures right before the confinement as baseline results. That would allow us to better identify the impact of confinement with its restrictions on the physical fitness of primary school students.

Conclusions

The explosive muscle power, leg muscle power, hand muscle power, and upper body muscle power increase with age. Agility in boys is constantly increasing from 8 to 10 years and in girls from 7 to 10 years. The speed is constantly increasing as children become older.

As children grow and develop, their physical fitness levels tend to change in response to various factors including different physical activity indicators. Vigorous physical activity is uniquely related to a better performance in hand muscle power and agility a year later. Practicing moderate-to-vigorous physical activity uniquely contributes to greater motor fitness even after controlling for sociodemographic variables, baseline motor fitness values, current BMI, as well as other physical activity-related factors at the moment or a year before. Physical activity enjoyment is also associated with greater motor physical fitness in primary school children.

A year after COVID-19 confinement returning to normal life and having regular physical education, physical activities, and sports as well as perceiving enjoyment from physical activity contribute to improvements in physical fitness and consequently primary school children’s health. Targeting these factors in any possible way in any life circumstances helps to maintain and/or strengthen children‘s health.

Conflict of Interest

The authors guarantee that no conflicts of interest exist.

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Зміна показників фізичної підготовленості дітей молодшого шкільного віку через рік після COVID-19 та її предиктори на індивідуальному рівні

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Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 10 с., 3 табл., 58 джерел.

Мета дослідження. Метою дослідження було оцінити фізичну підготовленість та її динаміку протягом року серед дітей молодшого шкільного віку від 7 до 10 років з урахуванням індивідуальних факторів дитини (пов'язаних зі здоров'ям: фізична активність, малорухлива поведінка; та психосоціальних: задоволення від занять фізичною активністю).

Матеріали та методи. Дослідження включало вибірку з 902 учнів 1-3 класів (49% хлопців і 51% дівчат), які взяли участь у тестуванні показників фізичної підготовленості на початковому етапі дослідження та в подальших спостереженнях протягом року. Крім того, було зібрано дані шляхом проведення анкетування учнів та їхніх батьків. Стан фізичної підготовленості оцінювали за допомогою восьми з дев'яти тестових завдань із батареї тестів з 9 пунктів, розробленої Фйортофтом та ін. (2011 р.). Зріст та вагу досліджуваних осіб вимірювали за допомогою механічної стадіометричної платформи (Seca 274, Гамбург, Німеччина; TEM50.01%) та портативних електронних ваг — TANITA BC 420 SMA (Tanita Europe BV, Амстердам, Нідерланди), відповідно. Рівень фізичної активності, малорухливої поведінки, участі у заняттях спортом, задоволення від занять фізичною активністю було оцінено дітьми та батьками в різні періоди часу.

Результати. Результати вказують, що від початкового етапу дослідження до подальшого спостереження спостерігалося покращення показників фізичної підготовленості, з деякими винятками для окремих тестів та представників обох статей. Високий рівень фізичної активності на 1 етапі прогностично сприяв поліпшенню показників сили м'язів кисті (Std β — стандартизований бета-коефіцієнт = 0,18) та спритності (Std β = -0,12) на 2 етапі дослідження. Як показали результати, участь у заняттях спортом на 1 етапі також була прогностично пов'язана з покращенням показників спритності (Std β = 0,15). Заняття фізичною активністю від помірного до високого рівня інтенсивності на 1 етапі дослідження прогностично сприяло підвищенню показників швидкості під час 2 етапу (Std β = -0,16). Встановлено, що мотивація до занять фізичною активністю на 2 етапі була пов'язана з покращенням рівня спритності (Std β = -0,18) та швидкості (Std β = -0,30), при цьому спостерігалося зниження показників сили м'язів кисті (Std β = -0,11). Загалом, за допомогою предикторів вдалося суттєво роз'яснити 10% результатів тесту на спритність і 13% результатів тесту на швидкість.

Висновки. У процесі росту та розвитку дітей, рівень їхньої фізичної підготовленості має тенденцію змінюватися у відповідь на різні фактори, включаючи різні показники фізичної активності, а також мотивацію до виконання фізичних навантажень.

Ключові слова: фізична підготовленість, діти молодшого шкільного віку, лонгітюдне дослідження, рухова підготовленість, підготовленість опорно-рухової системи.

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