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**PHYSICAL ACTIVITY BEFORE AND DURING  
COVID-19 PANDEMIC; ANALYSIS OF CHANGES  
AND CORRELATES IN CROATIAN  
ADOLESCENTS**

**TELESNA DEJAVNOST PRED IN MED  
PANDEMIJO COVID-19; ANALIZA SPREMENB  
IN KORELACIJ PRI HRVAŠKIH  
MLADOSTNIKI**

**ABSTRACT**

The COVID-19 pandemic affected the changes in physical activity levels (PAL). The purpose of this study was to determine the correlates of PAL during the COVID-19 pandemic among adolescents. This research included 209 adolescents aged 15-17 years from Croatia (89 boys, 120 girls). They were tested on anthropometrics, and fitness status (predictors). The fitness status was assessed before lockdown and included test of running 6 minutes (F6), jump rope, and sprint 100 meters. The PAL (assessed by the Physical Activity Questionnaire for Adolescents) was evidenced before- and during-lockdown and was observed as criteria. Changes in PAL between baseline and follow-up were evidenced by t-test for dependent samples. Associations between the fitness and anthropometric variables and PAL were evidenced by univariate and multivariate analyses. The PAL decreased significantly as a result of lockdown (t-test =3.46, p<0.001). In the total sample, significant correlations were found between aerobic endurance and sprinting, and baseline PAL (r=0.37; r=-0.32, respectively), aerobic endurance and follow-up PAL (r=0.34), sprint 100m and baseline to follow-up difference in PAL (r=-0.23). When gender stratified, correlations were significant only for boys. Better aerobic endurance determined baseline PAL, better sprint determined greater PAL decline as a result of lockdown. Results evidenced specific correlates of PAL before and during pandemic. Future studies investigating other correlates of PAL are warranted, to create interventions for maintaining adequate PAL during COVID-19 and similar crises.

*Keywords:* youth, physical education, outbreaks, health, exercise, pandemic

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**IZVLEČEK**

Pandemija COVID-19 je vplivala na spremembe ravni telesne dejavnosti (PAL). Namen te študije je bil ugotoviti korelate PAL med pandemijo COVID-19 med mladostniki. V pričujočo raziskavo je bilo vključenih 209 hrvaških mladostnikov, starih od 15 do 17 let (89 fantov, 120 deklet). Izmerili smo njihov telesni fitnes. Vzdržljivost smo ocenili pred začetkom karantene s preizkusom teka 6 minut (F6), preskakovanjem vrvi in šprintom na 100 metrov. PAL (ocenjen z vprašalnikom o telesni dejavnosti za mladostnike) je bila ocenjena pred in po karanteni.. Spremembe PAL pred in po karanteni smo dokazovali s t-testom za odvisne vzorce. Povezave med telesnim fitnesom in antropometričnimi spremenljivkami ter PAL smo ugotavljali z enosmernimi in multivariatnimi analizami. PAL se je zaradi karantene znatno zmanjšal (t-test = 3,46, p <0,001). V celotnem vzorcu so bile ugotovljene pomembne povezave med aerobno vzdržljivostjo in šprintom ter izhodiščno PAL (r = 0,37; r = -0,32), aerobno vzdržljivostjo in PAL po karanteni (r = 0,34), sprintom na 100 m in PAL pred in po karanteni – večja razlika v PAL (r = -0,23). Pri stratificiranih spolih smo ugotovili pomembne korelacije le pri dečkih. Rezultati prikazujejo posebne korelate PAL pred in med pandemijo. Prihodnje študije, ki raziskujejo druge korelate PAL so pomembne za vzdrževanje ustreznega PAL med COVID-19 in podobnimi krizami.

*Gljučne besede:* mladostniki, prekinitve športne vzgoje, zdravje, vadba, pandemija

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## INTRODUCTION

Physical activity (PA) is defined as “any bodily movement produced by skeletal muscles that results in energy expenditure” (Caspersen, Powell, & Christenson, 1985). It has different forms and intensities, including sports and organized exercise, fundamental movement skills, active play, leisure activities (walking, biking), active transport, and household activities (Caspersen et al., 1985). Adequate and consistent PA has numerous benefits for adolescents (Zenić, Rausavljević, & Berčić, 2006). Specifically, it develops a healthy musculoskeletal and cardiovascular system, improves metabolic health, and assists in maintaining a healthy body weight (Hallal, Victora, Azevedo, & Wells, 2006; Whooten, Kerem, & Stanley, 2019).

What is alarming, more than 80% of adolescents worldwide do not meet the recommended guidelines of 60 minutes of moderate-to-vigorous physical activity a day (Guthold, Stevens, Riley, & Bull, 2020). As PA is very important in maintaining and attaining a good health condition, numerous studies investigated factors that influence PA among adolescents. Specifically, gender (males are reported as more active), age (lower PA with increased age), living environment (urban adolescents are reported as more active), previous physical activity and sports status (previously active adolescents are reported as more active), parental and peer support (adolescents with social support are reported as more active) are considered as the most significant factors that influence PA (Bauman et al., 2012; Sallis, Prochaska, & Taylor, 2000; Sigmund, Froemel, Sigmundova, & Sallis, 2006).

The fast spread of the SARS-CoV-2 virus led to the declaration of the COVID-19 pandemic on March 11th, 2020 (Cucinotta & Vanelli, 2020). The main strategy for controlling the pandemic was the introduction of social distancing measures which included closures of schools, universities, café bars, sports-recreational facilities, and other places where a large number of people can gather (Bedford et al., 2020). Implemented measures led to decreased PA opportunities. Consequently, numerous studies reported a decrease in physical activity levels (PAL) caused by the imposed measures of social distancing during the pandemic (Caputo & Reichert, 2020). Briefly, a study conducted on the adult Italian population during the pandemic displayed a significant reduction of PAL with the most notable decrease among boys and overweight subjects (Giustino et al., 2020), which was also recorded among Spanish adults (Castañeda-Babarro, Arbillaga-Etxarri, Gutiérrez-Santamaría, & Coca, 2020). Similarly, study including adolescents and adults from Slovenia also reported decreased PAL (Pišot et al., 2020). The reduced PAL and increased sedentary behavior in Spain were confirmed among children

and adolescents (López-Bueno et al., 2020), which was also reported for Canadian and Irish children and adolescents (Moore et al., 2020; Ng, Cooper, McHale, Clifford, & Woods, 2020).

Similar to previously mentioned studies results from studies on adolescents from Croatia (coastal and continental region) and Bosnia and Herzegovina also reported a significant PAL decline due to the COVID-19 pandemic. Precisely, Croatian and Bosnian and Herzegovinian significantly declined their PAL, with a more evident decline reported for boys, adolescents living in the urban environment, and adolescents who had a conflict with their parents (Gilić, Ostojić, Čorluka, Volarić, & Sekulić, 2020; Sekulić, Blažević, Gilić, Kvesić, & Zenić, 2020; Zenić et al., 2020). Moreover, better fitness status and better paternal education determined the better PAL during the pandemic (Gilić et al., 2020; Sekulić et al., 2020). Likewise, a study conducted on urban adolescents from the Croatia, noted a significant decline in PAL during the 30-day lockdown due to COVID-19. The authors of that study reported that previously active participants decreased their PAL, while non-active participants increased their PAL during the lockdown (Karuc, Sorić, Radman, & Mišigoj-Duraković, 2020).

Collectively, studies frequently reported a significant decline of PAL during the COVID-19 confinement measures, which can have serious consequences on health, as even a small reduction in PAL can result in health deterioration (Narici et al., 2020). For that reason, correlates and factors that influence the change in PAL during the pandemic must be identified to create strategies for improving and maintaining adequate PAL. Therefore, the aim of this research was to investigate the factors that are associated with PAL before and during the pandemic, and changes in PAL among adolescents from Croatia, with special attention on anthropometric variables and fitness status.

## **METHODS**

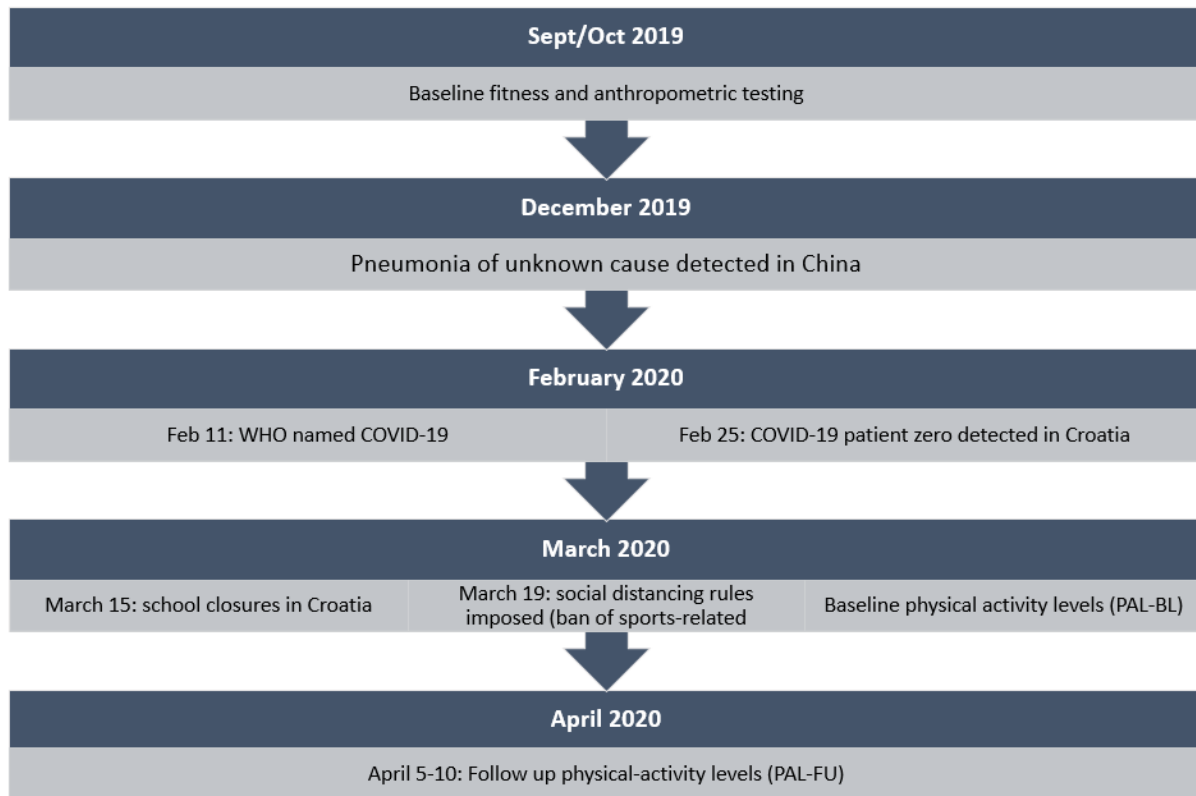
### **Participants**

This research included 209 adolescents ( $16.4 \pm 1.9$  years old) from Split, Croatia (89 boys, 120 girls). All participants were attending high school and were participating in regular classes of physical education (PE) two times a week. All participants included in this study were of good health, they did not have any medical condition (injury or illness) that could have reduced their regular participation in physical activity.

## Study design and variables

This prospective study consisted of two testing waves (baseline and follow-up) (Figure 1).

Figure 1. Time line of the research with most important dates regarding the COVID-19 pandemic.



The baseline was commenced 3-4 months before the COVID-19 pandemic imposed measures of social distancing and lockdown in the country (beginning of the school year 2019/20), and included anthropometric, fitness status testing, and baseline PAL assessment. The follow-up testing occurred during the period of lockdown due to the COVID-19 pandemic (from 5<sup>th</sup> to 10<sup>th</sup> of April 2020) and included PAL assessments (follow-up PAL). Originally, 214 participants were tested at baseline, and there was a drop out of 5 participants at follow-up testing. Therefore, the total number of participants who were tested at both baseline and follow-up was 209.

PAL was assessed by the Physical Activity Questionnaire for Adolescents (PAQ-A) by using the online platform SurveyMonkey (SurveyMonkey Inc., San Mateo, CA). PAQ-A is a 7-day recall questionnaire consisted of 9 items. The First 8 items are used for evaluating activity during physical education classes, during sports, free play, and active transportation, and the 9<sup>th</sup> item questions whether a participant had any kind of injury or illness that could have prevented

him to participate in regular PA. Item one to eight ranged from 1 to 5, 1 represented low PAL and 5 represented high PAL. The final PAQ-A score was calculated as the mean value of the first 8 items. PAQ-A results ranged from 1 to 5, evidencing low or high PAL, respectively. PAQ-A was administered both at baseline and follow-up testing, and the difference in PAL represented the change in PAL between baseline and follow-up PAL, as a result of implemented social-distancing measures during the COVID-19 pandemic.

Fitness tests used in this study are regularly used in the Croatian educational system to track the physical fitness of school-age children (Findak, Metikoš, Mraković, & Neljak, 1996). In brief, F6 was used for estimating aerobic endurance. Participants had 6 minutes to run the greatest distance as they can, and results were presented as the total distance covered in meters. The Jump-rope test was used for evaluating the coordination of the children. Participants had 60 seconds to perform consecutive jumps using the jump rope adjusted for height. The number of successful jumps represented the final result. Sprint 100 m was used for assessing running speed performance (anaerobic capacity). Participants were standing behind the start line and on the mark of the investigator (PE teacher), they had to run as fast as possible the 100 meters distance. The time needed to run the distance was recorded using the stopwatch, results were reported in seconds. Body height (BH) was measured with the measuring tape placed on the wall, it was expressed in centimetres (cm). Body mass (BM) was measured with a calibrated scale (Digitron, Buje, Croatia) and was expressed in kilograms (kg). The Body mass index [ $BMI = \text{body mass}(\text{kg}) / \text{body height}(\text{m})^2$ ] adjusted for age and gender as proposed by International Obesity Task Force (IOTF cut-offs) represented the BMI-z variable.

### **Statistical analyses**

The normality of the distribution of variables was checked by the Kolmogorov-Smirnov test for normality of distribution, and all variables were normally distributed (except gender). Changes in PAL between baseline and follow-up were evidenced by t-test for dependent samples. Associations between the fitness and anthropometric variables and PAL were evidenced by univariate and multivariate analyses. Univariate correlations were determined by Pearson's correlation coefficients. Multiple regressions were calculated to evaluate the multivariate associations between predictors (fitness and anthropometric variables) and criteria (PAL). All analyses were calculated for the total sample, and then gender stratified, and correlation coefficients obtained for boys and girls were statistically compared.

Statistical significance was set to  $p < 0.05$ . All analyses were performed by using Statistica 13.5 (Tibco Inc., Palo Alto, CA).

## RESULTS

Table 1 presents results of descriptive statistics for PAQ-A scores and changes in PAQ-A scores between baseline and follow-up. PAL significantly decreased in total sample (t-test = 3.54,  $p < 0.001$ ) and in boys (t-test = 5.17,  $p < 0.001$ ). No significant differences in PAQ-A scores were evidenced in girls (t-test = 0.13,  $p = 0.79$ ).

Table 1. Descriptive statistics and changes in PAQ-A scores between baseline and follow-up measurement.

	Baseline		Follow-up		T-test	
	Mean	SD	Mean	SD	t-value	p
Total sample	3.04	0.61	2.81	0.81	3.54	0.00
Boys	3.13	0.76	2.90	0.85	5.17	0.00
Girls	2.78	0.65	2.80	0.70	0.13	0.79

Boys were significantly taller and heavier and achieved better results in fitness tests than girls (Table 2).

Table 2. Descriptive statistics and differences between boys and girls in anthropometric and fitness indices (t-test for independent samples).

	Boys		Girls		t-test	
	Mean	SD	Mean	SD	t-value	p
BH (cm)	182.67	13.13	169.90	6.76	10.21	0.001
BM (kg)	73.43	12.50	60.61	8.17	10.41	0.001
BMI ( $\text{kg}/\text{m}^2$ )	25.79	2.19	20.95	2.10	0.73	0.47
100m (s)	12.69	1.72	15.03	1.38	-10.98	0.001
Jump rope (rep)	63.36	13.32	59.76	12.72	2.51	0.01
F6 (m)	1332.65	140.19	1211.22	129.11	2.60	0.01

LEGEND: BH – Body height; BM – Bodymass, BMI-z - Body mass index z-value; 100m – sprint on 100 meters; F6 – test running 6 minutes

In the total sample, significant correlations were found between aerobic endurance and sprinting, and baseline PAL ( $r=0.37$ ;  $r=-0.32$ , respectively), aerobic endurance and follow-up PAL ( $r=0.34$ ), and sprint 100m and baseline to follow-up difference in PAL ( $r=-0.23$ ).

However, when separated by gender, correlations were significant only for boys, with significant ( $p < 0.05$ ) difference between correlation coefficients obtained for boys and girls in F6 (baseline and follow-up PAL), and sprint 100m (PAL difference) (Table 3).

Table 3. Pearson's product moment correlations between fitness and anthropometric variables, and baseline, follow-up physical activity levels, and the difference between baseline and follow-up physical activity levels.

Variables	Total Pearson's R	Boys Pearson's R	Girls Pearson's R
<b>Baseline physical activity levels</b>			
BH	0.07	-0.05	0.06
BM	0.04	-0.11	0.04
BMI-z	0.00	-0.01	0.00
100m (-)	-0.32*	-0.26*	-0.14
Jump rope	0.01	-0.03	0.01
F6	0.37*	0.38*	0.01
<b>Follow-up physical activity levels</b>			
BH	0.01	-0.03	0.01
BM	-0.03	-0.09	-0.04
BMI-z	0.00	-0.00	-0.06
100m (-)	-0.09	0.03	-0.17
Jump rope	-0.00	0.01	-0.05
F6	0.34*	0.34*	0.01
<b>Difference between baseline and follow-up physical activity levels</b>			
BH	0.09	-0.00	0.05
BM	0.11*	0.00	0.09
BMI-z	-0.00	-0.01	0.08
100m (-)	-0.23*	-0.32*	0.04
Jump rope	0.05	0.00	0.07
F6	0.02	0.03	0.08

LEGEND: BH – Body height; BM – Body mass, BMI-z - Body mass index z-value; 100m – sprint on 100 meters; F6 – test running 6 minutes\* denotes statistical significance of  $p < 0.05$ ; (-) indicates opposite metrics, a lower numerical value is evidenced as a better achievement.

Better aerobic endurance determined baseline PAL, while better sprint performance determined greater PAL decline as a result of lockdown (Table 4).

Table 4. Multiple regression results between fitness and anthropometric variables (predictors) and levels of physical activity (criteria) at baseline, follow-up, and the difference between baseline and follow-up for boys and girls.

Predictors	Boys (n= 89)		Girls (n=120)	
<b>Physical activity levels at baseline</b>				
	$\beta$	b	$\beta$	b
BH	-0.21	-0.02	0.02	0.00
BM	0.27	0.01	0.07	0.01
100m(-)	-0.15	-0.06	-0.09	-0.04
Jump rope	-0.18	-0.01	-0.06	-0.00
F6	0.34*	0.40*	0.15	0.18
R	0.42		0.21	
R <sup>2</sup>	0.18		0.04	
p	0.01		0.39	
<b>Physical activity levels at follow-up</b>				
BH	0.04	0.00	-0.00	-0.00
BM	0.05	0.00	-0.03	-0.00
100m(-)	0.10	0.05	-0.16	-0.09
Jump rope	-0.12	-0.01	-0.12	-0.01
F6	0.20	0.27	0.09	0.13
R	0.21		0.22	
R <sup>2</sup>	0.05		0.05	
p	0.56		0.35	
<b>Difference between baseline and follow-up physical activity levels</b>				
BH	-0.25	-0.02	-0.00	-0.00
BM	0.21	0.01	0.13	0.01
100m(-)	-0.31*	-0.11*	0.07	0.04
Jump rope	-0.03	-0.00	0.09	0.00
F6	0.08	0.08	0.05	0.07
R	0.36		0.17	
R <sup>2</sup>	0.13		0.03	
p	0.03		0.65	



## DISCUSSION

The main findings from this study are: (i) aerobic endurance and sprint were significantly correlated with baseline PAL in boys, (ii) aerobic endurance and follow up PAL were significantly correlated in boys, and (iii) better sprinting determined the PAL decline in boys. Before discussing those findings, we will briefly overview the decrease of PAL between baseline and follow-up.

This study evidenced a significant decrease of PAL caused by imposed movement restrictions during the COVID-19 pandemic. This finding is in accordance with numerous previous studies (Caputo & Reichert, 2020; Sekulić et al., 2020). However, in our sample, changes were observed for the total sample, but when gender stratified, a decrease was significant only for boys. This could be caused by the nature of the physical activity that boys participate in. Precisely, boys are generally more involved in organized sports training (i.e. competitive sports) than girls. Thus, as all sports clubs were closed during the COVID-19 lockdown, it is logical that boys had a greater PAL decline than girls. Supportively, even previous studies confirmed a larger decrease of PAL than among girls (Giustino et al., 2020; Sekulić et al., 2020). Additionally, boys achieved better results in all fitness variables than girls which can be also explained with regularly higher PAL and participation in organized sports of boys.

Aerobic endurance and sprinting were positively correlated with baseline PAL in boys. Specifically, boys who had better aerobic endurance and better sprint capacities had higher baseline PAL. This could be explained by the fact that there were no implemented strict measures of social distancing during the time of the baseline testing, hence, schools, sports clubs, and facilities were opened (Zenić et al., 2020). Therefore, children were able to participate in their regular sports training and other forms of physical activities.

It is reasonable to assume that adolescents who participate in organized sports and recreational activities have better aerobic endurance and sprinting capacities, and higher PAL (Chen, Hammond-Bennett, Hypnar, & Mason, 2018). Therefore, adolescents with better aerobic endurance and sprinting capacity logically have higher PAL during regular-life situations. This is supportive of a previous study conducted on a similar sample of adolescents from Croatia. Namely, Sekulić et al. (2020) reported that aerobic and anaerobic endurance capacities displayed the most significant association with PAL before the COVID-19 lockdown (Sekulić et al., 2020).

Aerobic endurance was positively correlated with PAL during the pandemic (follow-up PAL). The reason for this could be found in the assumption that adolescents who participate in endurance sports, such as running and cycling, have better aerobic capacity. What is more, those adolescents had opportunities to continue with training even during the pandemic. Indeed, adolescents with better aerobic endurance are generally more prone to physical activities in “open-air” which were not prohibited even during the lockdown period. For explaining this, the situation during the COVID-19 lockdown in the region where sample was drawn from will be presented briefly. Specifically, even though clubs and sports facilities were closed, people were allowed (and even encouraged) to spend time outside. This was possible with taking care to maintain the recommended social distance. Consequently, citizens were able to practice their sport during the lockdown in open-air. Additionally, weather in this region in the period of lockdown was mostly sunny and warm (temperature higher than 10°C). Therefore, any kind of physical training in parks, forests, and streets was possible (Zenić et al., 2020). Collectively, type of activity/sport, weather conditions, and the possibility to spend time outdoors impacted even the here reported results (i.e., adolescents with better aerobic endurance were reported to have better PAL during the pandemic).

The most notable finding of this study was that boys who had better sprinting results evidenced the most significant PAL decline. There is no doubt that adolescents who had better sprinting capacities were involved in organized sports. In the studied region, the most popular sports among boys include team sports such as soccer, basketball, and handball, which require and develop sprinting and other kinds of power capacities (Vilhjalmsson & Kristjansdottir, 2003). However, these types of sports training were banned during the pandemic and boys with pre-pandemic high PAL (as a result of participation in team sports) declined PAL as a result of the imposed restrictions.

All previously stated is supported by findings of a recent study conducted on adolescents from Zagreb, Croatia. Authors reported that adolescents who had sufficient PAL before the pandemic decreased their PAL during the pandemic in comparison to previously inactive adolescents who oppositely increased their PAL during the 30 days of lockdown (Karuc et al., 2020). They explained their results by the fact that active people require more space, facilities, and equipment for exercising/training. Since all of the above mentioned was reduced and restricted during the COVID-19 pandemic lockdown, it was expected that people with initial high PAL will display PAL reduction (Karuc et al., 2020). Supportively, to all previously discussed, our

results evidenced non-significant changes in PAL (with slight, although insignificant increase of PAL) among girls, who are consistently less physically active than boys.

## **CONCLUSION**

The results of this study suggest that adolescents with better fitness status had better pre-pandemic PAL. However, adolescents with better sprinting capacities declined their PAL to a greater extent as a result of the implemented restrictions, probably as a consequence of the lack of organized sports activities. Also, boys were better at all fitness status variables compared with girls, what can be a consequence of generally higher PAL of boys. Significant difference was evidenced between correlation coefficients for boys and girls in endurance and sprinting capacities. This study expands the knowledge on the problem of declined PAL during the COVID-19 pandemic, as it determines the factors that influence PAL and changes in PAL. However, studies investigating the problem in more detail, with a focus on other determinants of PAL, are warranted. The applicability of this and similar studies is found in the possibility that authorities and experts in PE and sports training may create targeted programs that can be used during the pandemic and similar situations with reduced movement opportunities. Those programs could be offered as online applications or platforms and social networks, specially designed for situations with limited equipment and space. Special emphasis should be placed on creating adequate programs for athletes (especially boys) in circumstances of lockdown.

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## **Declaration of Conflicting Interests**

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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