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Analyzing the Associations between Physical Literacy, Physical Activity Levels, and Sedentary Behavior: Cross-sectional Study in Preadolescent Children

Antea Sipalo Lilic[1], Petra Rajkovic Vuletic[1,2], Miran Pehar[3], Edin Uzicanin[4], Ivana Cerkez Zovko[3], Belmin Bujakovic[3], Natasa Zenic[1]

[1]University of Split, Faculty of Kinesiology, 21000 Split, Croatia, [2]University of Zagreb, Faculty of Kinesiology, 10000 Zagreb, Croatia, [3]University of Mostar, Faculty of Science and Education, 88000 Mostar, Bosnia and Herzegovina, [4]University of Tuzla, Faculty of Sport and Physical Education, 75000 Tuzla, Bosnia and Herzegovina

Abstract

Physical literacy (PL) is considered an important determinant of physical activity level (PAL), but studies have rarely examined the associations between PL and PAL in preadolescents. This study aimed to evaluate associatios between PL, PAL and sedentary behavior (SB) in preadolescents from southeastern Europe. The participants were 9- to 11-year-old children from Croatia and Bosnia and Herzegovina (n=333, 52% girls) who were tested for PL, PAL and SB. The PLAYself questionnaire was used for the evaluation of PL, while PAL was estimated by data provided throughout the Physical Activity Questionnaire for Children (PAQ-C). Pearson's correlations and multiple regressions were calculated to identify the associations between study variables. The results revealed a significant correlation between PL and PAL in the total sample (16% of the common variance) among boys (10% of the common variance) and girls (25% of the common variance), which was additionally confirmed by multiple regression calculated between the PL subdomains and PAL (R2=0.23, 0.15, and 0.31 for total sample, boys and girls, respectively). The SB was not significantly correlated with PL (<2% of the common variance; p>0.05) or with PAL (<1% of the common variance; p>0.05). The results indicated a stronger association between PL and PAL in girls than in boys, indicating the possible influence of the types of physically demanding activities children are involved in on the studied associations. To explore causality more specifically, intervention studies are warranted.

Keywords: prepubescent children, questionnaire, regression, correlation

Introduction

There is strong evidence that physical activity (PA) has multiple benefits for children and adolescents, improving physical and mental health, sleep quality, brain development, bone health, and social, psychological, and cognitive health (Alvarez-Pitti et al., 2020). Furthermore, PA is recognized as an important factor in the prevention of overweight and obesity (Ariza et al., 2019). However, despite the current knowledge on the benefits of PA, there is an increasing level of sedentary behavior characterized by low physical activity levels (PAL). Unfortunately, the majority of the young population is not physically active, and global reports indicate that >80% of children and adolescents do not have sufficient PAL (Guthold, Stevens, Riley, & Bull, 2020; Kuna, Duvnjak,

& Sklempe Kokić, 2023). Of particular concern is that recent reviews of scientific papers emphasize that a progressive decline in moderate to severe PAL occurs even before adolescence, beginning between early and middle childhood, that is, between the ages of six and nine (Farooq et al., 2020; Vukelja, Milanovic, & Salaj, 2022). Therefore, it is necessary to investigate methods to increase the level of PAL in children and determine the factors associated with it. As one of the novel solutions, the concept of physical literacy (PL), which is considered a key factor that leads to an increase in the PAL was proposed (Caldwell et al., 2020; Geets-Kesić, Maras, & Gilić, 2023)

Physical literacy (PL) is defined as "the motivation, confidence, physical competence, knowledge, and understanding to value and take responsibility for engagement in physical activities for life (Whitehead, 2013). The concept of PL encompasses the development of skills, knowledge and attitudes that empower individuals to lead a physically active lifestyle throughout their lives and, as such, emphasizes the importance of encouraging lifelong engagement in PA. Although different concepts of PL and tools for assessing the level of PL have been developed around the world, there is no consensus on which is the most appropriate (Longmuir & Tremblay, 2016). However, the most popular and commonly used tools for assessing PL are the Canadian Assessment of Physical Literacy (CAPL) and the Physical Literacy Assessment of Youth (PLAY; de Dieu & Zhou, 2021). Recent studies have shown better reliability and validity of the PLAY questionnaire in the evaluation of PL in preadolescents (Vuletic et al., 2023). This is important to highlight because, from the aspect of the development of lifelong participation in PAs, preadolescence is a crucial period.

More precisely, the PL recognizes several subdomains, including (1) the physical domain (which includes motor skills and physical capacity), (2) the affective domain (which includes motivation and confidence) and (3) the cognitive domain (which includes knowledge and understanding). These subdomains are interrelated and are critical for supporting participation in PA. Therefore, encouraging the development of PL in children from an early age is important for a lifelong active and healthy lifestyle. However, although it can be assumed that PL and PA are related, studies have rarely investigated their associations in children and adolescents, and the results are generally inconsistent. In brief, Canadian studies have shown a certain positive association between PL and PAL in children aged 8 to 12 years (Belanger et al., 2018; Stearns, Wohlers, McHugh, Kuzik, & Spence, 2019). Similar results were reported in another Canadian study of children aged 7-14 years (Bremer et al., 2020). Moreover, a study performed in China on adolescents aged 12 to 18 years evidenced a low (although significant) correlation between PL and PAL (Choi, Sum, Leung, & Ng, 2018). Finally, a recent Croatian study revealed a significant correlation between PL and PAL in girls aged 9-11 yers but not among boys of the same age (Rajkovic Vuletic et al., 2024).

From the previous literature overview, it is clear that there is increased interest in the association between PL and PAL in children (Belanger et al., 2018; Bremer et al., 2020; Choi et al., 2018; Stearns et al., 2019). However, the majority of previous studies used various instruments for PL assessments that focused on motor competence (e.g., the Canadian Agility and Movement Skill Assessment, PLAYfun) and cog-

nitive domains (knowledge and understanding), while there are few studies that have used the PLAYself to assess the cognitive and affective domains of PL in younger children (Stearns et al., 2019). Furthermore, studies performed thus far included samples of participants of relatively wide age spans, which could influence the reported findings simply because of the known decrease in PAL with the age of the children (Bremer et al., 2020; Choi et al., 2018). Therefore, the aim of this study was to investigate the association between PL levels assessed with PLAYself and PAL in an international sample of children aged 9-to-11 years from southeastern Europe. Additionally, we evaluated an association between sedentary behavior and PAL in preadolescents.

Materials and methods
Participants

This study involved preadolescent children (n=333; 170 girls) from Croatia and Bosnia and Herzegovina. All participants were in good health, attended the 3rd or 4th grade of elementary school (4th and 5th in Bosnia and Herzegovina), and regularly attended physical education (PE) classes. During the research, all participants were aged between 9 and 11 years. Children who were ill or had an injury affecting their movement in the two weeks before the examination were not included in the study. The research team informed the parents or guardians about the research's objectives and procedures and obtained their consent for their children's participation. This research was approved by the Ethics Committee of the Faculty of Kinesiology, University of Split.

Variables and procedures

In addition to age (years), sex (male or female), we observed PL, PAL and sedentary behavior (SB). The PL was assessed using the PLAYself questionnaire, which is a component of the PLAY tools (PLAYfun, PLAYbasic, PLAYself, PLAYparent, PLAYcoach, and PLAYinventory). This questionnaire is used by children and adolescents for self-assessment of their PL level and has four subdomains: (i) Environment, which assesses the degree of confidence of movement in different environments (e.g., activities in the gym, in and on water, and on snow and ice), including questions such as "How good are you at doing sports and activities in the gym?" or "How good are you at doing sports and activities in and on the water?" (ii) Self-reports of PL, which assess a number of affective and cognitive segments (e.g., motivation, confidence, and self-esteem) related to PL that determine an individual's self-efficacy and ability to participate in PA, including questions such as "It does not take me long to learn new skills, sports or activities" or "I think I can take part in any sport/PA that I choose". (iii) The relative ranking of literacy with its subdomains of literacy, numeracy, and physical literacy assesses literacy in different environments (e.g., school, home, and friends) and evaluates the importance that an individual places on each of the mentioned literacies. (iv) The level of fitness is assessed by the following question: "My state of fitness is good enough to allow me to participate in all the activities I choose". This subdomain is excluded from the final PLAYself score. The overall result of the questionnaire is calculated by summing the points from the first three subdomains and dividing by the total number of questions (27 in total). The maximum possible self-concept score for PL is 100, and it is represented

by PLAY self points. The Croatian version of the PLAYself questionnaire has recently been shown to be feasible, valid, and reliable in Croatian children aged 9 to 11 years (Vuletic et al., 2023).

PAL was evaluated using the "Physical Activity Questionnaire for Older Children" (PAQ-C) (Crocker, Bailey, Faulkner, Kowalski, & McGrath, 1997). The PAQ-C-Croatian version of the questionnaire for assessing the level of PA was constructed for children of similar age (from 8 to 14 years) to assess the overall level of arithmetical PA (Samaržija & Mišigoj-Duraković, 2013). The questionnaire comprises 9 questions that are evaluated on a 5-point scale, for example, "In the last 7 days, what did you mostly do during a long break (except eating a snack)?" and In the last 7 days, during your physical education (PE) classes, how often were you very active (playing hard, running, jumping, throwing)?". The total score for PA was determined by calculating the mean of the responses provided. A maximum PAQ-C score of 5 represented high activity, while a score of 1 represented very low or no activity.

The level of SB was evaluated by a questionnaire consisting of questions about the time children spent in six different groups of behaviors in hours and minutes per day: (1) watching television, (2) playing computer games, (3) browsing the internet, (4) homework and studying, (5) listening to music, and (6) reading (Štefan, Horvatin, & Baić, 2019).

Statistical analysis

The normality of the variables was tested with the Kolmogorov–Smirnov test. For normally distributed vari-

ables, means and standard deviations were reported, while counts and percentages were reported for categorical and ordinal variables.

Differences between boys and girls were evidenced by t-test for independent samples.

The associations between study variables were first established by calculating the Pearson's product moment correlation coefficients. In the next phase, multiple regressions were performed with PAL as the criterion and different subdomains/facets of PL as predictors. Generally, multiple regressions were calculated between facets of PL and PAL, due to established correlations (please see previous phase, and Results for more details). The coefficient of the multiple correlation (R), coefficients of determination (R2), standardized (β) and nonstandardized (B) regression coefficients are reported.

Statistica ver 13.5 (Tibco Inc., Palo Alto, CA, USA) was used for all calculations, and a p-level of 95% was applied.

Results

The descriptive statistics and differences between sexes in the study variables are presented in Table 1. Boys and girls were of the same age, and no significant differences were found between boys and girls for the PL subdomains or total PL score. However, boys had greater PAL (t test =2.55, p<0.01) and less sedentary time than girls did (t test =3.37, p<0.001).

The Pearson's product moment correlation coefficients between the study variables calculated for the total sample and for girls and boys are presented in Table 2. No significant correlation between SB and PL or PAL was detected. PAL

Table 1. Descriptive statistics and differences between boys and girls

	Girls (n = 170)		Boys (n = 163)		t test	
	Mean	**Std.Dev.**	**Mean**	**Std.Dev.**	**t value**	**p-level**
Age (years)	9.99	0.66	9.95	0.74	0.61	0.54
PL-1 (score)	361.13	120.70	353.35	113.98	0.61	0.55
PL-2 (score)	891.88	163.51	915.95	146.41	-1.42	0.16
PL-3 (score)	228.83	64.68	222.52	71.61	0.84	0.40
PL-4 (score)	236.17	63.20	224.68	75.61	1.50	0.13
PL-5 (score)	253.54	60.42	259.76	52.15	-1.01	0.31
PLAYself (score)	73.02	12.27	73.19	11.03	-0.14	0.89
SB (score)	19.04	5.98	21.62	7.86	-3.37	0.001
PAQ-C (score)	3.02	0.63	3.21	0.73	-2.55	0.01

Note. PL-1 – environment subdomain of the PLAYself questionnaire; PL-2 – self-description subdomain of the PLAYself questionnaire; PL-3 – literacy subdomain of the PLAYself questionnaire; PL-4 – numeracy subdomain of the PLAYself questionnaire; PL-5 – physical literacy subdomain of the PLAYself questionnaire; PLAYself – total score for the PLAYself questionnaire; SB – sedentary behavior; PAQ-C – physical activity level obtained by the PAQ-C questionnaire

was significantly correlated with the first two subdomains of the PL in the total sample (<17% of the common variance), in girls (<25% of the common variance), and in boys (<20% of the common variance). Additionally, the correlation between PAL and the PL total score reached statistical significance for the total sample (16% of the common variance), girls (25% of the common variance), and boys (10% of the common variance).

The results of the multiple regression calculations for the PAQ-C as criterion variables with the PL subdomains/facets and PL-total score as predictors are presented in Table 3.

Predictors explained a significant proportion of the variance in the criterion when regressions were calculated for the total sample and separately for boys and girls (23%, 15%, and 31% of the explained variance, respectively). In the total sample, significant partial predictors were the first two facets of PL (β=0.31 and 0.24, respectively). The first facet of the PL was a significant partial predictor for boys (β=0.28), while the first two facets were significantly partially associated with the criterion for girls (β=0.38 and 0.23, respectively). In general, the positive association between specific PL facets and PAL should be highlighted.

Table 2. Correlation between study variables for the total sample of participants and stratified by sex (* indicates coefficients significant at p<0.05)

		PL-1	PL-2	PL-3	PL-4	PL-5	PLAYself	SB
PL-1	Total	-						
	Girls	-						
	Boys	-						
PL-2	Total	0.50*	-					
	Girls	0.46*	-					
	Boys	0.51*	-					
PL-3	Total	0.11*	0.22*	-				
	Girls	0.11	0.25*	-				
	Boys	0.06	0.11	-				
PL-4	Total	0.11	0.19*	0.69*	-			
	Girls	0.16*	0.26*	0.69*	-			
	Boys	0.01	0.05	0.67*	-			
PL-5	Total	0.21*	0.33*	0.49*	0.50*	-		
	Girls	0.17*	0.32*	0.55*	0.63*	-		
	Boys	0.19*	0.23*	0.40*	0.38*	-		
PLAYself	Total	0.69*	0.81*	0.59*	0.58*	0.62*	-	
	Girls	0.67*	0.82*	0.59*	0.63*	0.63*	-	
	Boys	0.69*	0.77*	0.56*	0.51*	0.55*	-	
SB	Total	0.00	0.06	0.04	0.00	0.09	0.06	-
	Girls	0.02	0.05	0.02	0.12	0.01	0.06	-
	Boys	-0.04	-0.03	0.02	-0.09	0.08	-0.04	-
PAQ-C	Total	0.43*	0.40*	0.07	0.10	0.19*	0.42*	0.06
	Girls	0.50*	0.43*	0.14	0.20*	0.20*	0.50*	0.08
	Boys	0.35*	0.29*	-0.03	-0.01	0.06	0.28*	-0.05

Note. PL-1 – environment subdomain of the PLAYself questionnaire; PL-2 – self-description subdomain of the PLAYself questionnaire; PL-3 – literacy subdomain of the PLAYself questionnaire; PL-4 – numeracy subdomain of the PLAYself questionnaire; PL-5 – physical literacy subdomain of the PLAYself questionnaire; PLAYself – total score for the PLAYself questionnaire; SB – sedentary behavior; PAQ-C – physical activity level obtained by the PAQ-C questionnaire

Table 3. Multiple regression calculation for physical activity level as a criterion variable for the total sample and stratified by sex (* indicates coefficients significant at p<0.05)

	Total sample		Boys		Girls	
	β	B	β	B	β	B
Intercept		1.41*		2.02*		1.31*
PL-1	0.31*	0.00*	0.28*	0.00*	0.38*	0.00*
PL-2	0.24*	0.00*	0.15	0.00	0.23	0.00*
PL-3	-0.07	0.00	-0.09	0.00	-0.03	0.00
PL-4	0.04	0.00	0.04	0.00	0.08	0.00
PL-5	0.05	0.00	-0.01	0.00	0.03	0.00
R	0.48		0.38		0.55	
R2	0.23		0.15		0.31	
p	0.001		0.001		0.001	

Note. PL-1 – environment subdomain of the PLAYself questionnaire; PL-2 – self-description subdomain of the PLAYself questionnaire; PL-3 – literacy subdomain of the PLAYself questionnaire; PL-4 – numeracy subdomain of the PLAYself questionnaire; PL-5 – physical literacy subdomain of the PLAYself questionnaire; R – coefficient of multiple correlation; R2 – coefficient of determination; p – level of significance; β – standardized regression coefficient; B – nonstandardized regression coefficient

Discussion

The few most important findings of this study are discussed in the following text. First, despite the significant correlation between PL and PAL in the total sample of participants, these associations were weak. Second, the correlation between PL and PAL was greater among girls than among boys. Third, SB was not significantly associated with PL in the studied preadolescent children.

Low correlation between PL and PAL in the total sample

To the best of our knowledge, few studies have investigated the correlations between PL and PAL in preadolescent children. Additionally, the results are generally inconsistent. In brief, when studying a large sample of Canadian children, Belanger et al. reported that children who met PA guidelines had greater PL, confirming a positive correlation between PL and PAL (Belanger et al., 2018). In another Canadian study, the PL of preadolescent children was also significantly associated with PAL, as evaluated through moderate-to-vigorous PAL (Caldwell et al., 2020). However, in both previously presented investigations, the sample of participants was "one", not dividing boys from girls or younger from older children (although the authors included gender/sex as covariate in the calculated regression models). Moreover, a very recent Croatian study performed with preadolescents revealed a positive correlation between PAL and PL (i) in girls but not in boys and (ii) in older (4th graders) and not younger (3rd graders) children (Rajkovic Vuletic et al., 2024). Therefore, our results on the generally poor (although significant) association between PL and PAL when preadolescents were observed as a unique sample are in line with previous reports. There are several possible explanations for such findings, which we will discuss in the following text.

First, the self-evaluation of the PL is based on one's perception of (personal) physical abilities and physical competencies in comparison to those of other people (i.e., peers, friends, schoolmates) (Vuletic et al., 2023). Therefore, the children observed in this study compared themselves to others who were participating in activities where physical competencies were present (i.e., sport training, PE, and free play). Naturally, boys compared themselves with boys, while girls compared themselves with peer girls. When translated to the PL scale, there was no significant difference between boys and girls in the PL subscale. However, it is well known that the PLs of boys and girls are not similar, even in preadolescence. Overall, this approach results in specific bias in the scoring of the PL and translates to the calculation of the correlation between the PL and PAL when calculated for the total sample of participants (not dividing boys and girls).

Second, despite previous findings, there is a certain possibility that in this period of life, PL and PAL are not as associated as they appear later in life. Specifically, although there is a global consensus that PL is an important determinant of PAL in life and that "physically literate" individuals will have greater PAL, the association between PL and PAL is expected to be stronger in adulthood. Namely, at younger ages children are physically active irrespective of their physical literacy simply because (i) young children are frequently engaged in free play and (ii) most of them participate in PE (Veitch, Salmon, & Ball, 2010). In other words, in this period of life, PA is not determined and conditioned by "physical competence", as is the case in later life. Taken together, these facts ecologically decrease the correlation between PL and PAL in preadolescence.

Differences in correlations between PAL and PL for boys and girls

Interestingly, sex-stratified analyses of the correlations between PL and PAL are not common. This is particularly important considering that studies thus far have confirmed (i) nonsignificant gender/sex differences in PL between genders during childhood and adolescence and (ii) gender/sex differences in magnitude of correlations between PL and

PAL (Rajkovic Vuletic et al., 2024; Vuletic et al., 2023). For example, research on preschool children revealed that the PL is predictive of PAL in girls but not in boys (Cairney et al., 2018). Similarly, the authors found no significant correlation between PL and PAL in preadolescent boys, but a significant correlation between PL and PAL was found in same-age girls from Croatia (Rajkovic Vuletic et al., 2024). Although our results are not entirely consistent with those of previous reports (i.e., we found a significant correlation for both boys and girls), our findings support those of previous studies. Namely, the correlation we have evidenced for girls is almost twice as large as the correlation evidenced for boys.

The first issue that deserves attention in explaining sex-specific associations between PL and PAL is free-play. Free-play (i.e., participation in nonstructured activities) is a significant source of PA in preadolescence (Rajkovic Vuletic et al., 2024). Additionally, in the region where this study was conducted, boys are regularly involved in physically demanding nonstructured activities, while girls participate in physically less demanding games (Maric et al., 2020). Moreover, although it is an important source of PA, participation in nonstructured physically demanding activities is not as strongly associated with PL, as is the case for structured activities (PE and organized sport participation), where PL is specifically accentuated and developed (Sunda et al., 2022). On the other hand, the PAL of girls is more a result of participation in structured activities, such as PE and organized sports, where coaches and PE teachers specifically emphasize PL. As a result, girls who are physically active are more likely to be "physically literate".

Another explanation for the finding that PL and PAL are more strongly associated in girls than in boys is based on practical/professional knowledge of the authors who are long-term professionals in PE and sport. In brief, the authors share the opinion that participation in any kind of physically demanding activity in girls is accompanied by a certain profound interest in the activity itself. In other words, girls rarely participate in any form of PA if they are not "interested in it". Meanwhile, boys are frequently engaged in physically demanding activities (only) emotionally to compete and win. This is supported in studies where authors described the motives for being physically active between genders/sexes. In brief, boys are often motivated by competition, social recognition, and challenges, while girls are more likely to be motivated by intrinsic factors such as fun and being with friends (Portela-Pino, Lopez-Castedo, Martinez-Patino, Valverde-Esteve, & Dominguez-Alonso, 2019). Consequently, girls' participation in PA (i.e., PE, sport) actually leads to better PL than is the case for boys, resulting in a greater correlation between PAL and PL among girls.

Lack of correlation between SB and PL in preadolescence

Although sedentary behavior is often considered a habit that is directly opposed to PA, the association between PAL and SB has not been frequently explored. Most of the related studies have examined problems in late adolescence and young adulthood, and the related research has yielded mixed results. In brief, when authors summarized studies performed with children and adolescents, Pearson et al. reported a small negative association between sedentary behavior and PA in children and adults (Pearson, Braithwaite, Biddle, van Sluijs, & Atkin, 2014). In contrast, a more recent study revealed a

weak but positive correlation between SB and PA in undergraduate students (de Andrade Leão, dos Santos, & da Silva, 2018). Therefore, our finding of a nonsignificant association between sedentary time and PAL is not surprising.

Indeed, SB is a certain counterpoint of physically active behavior. It is logical to consider that people who have greater SB are less physically active. For that reason, "sedentarism" (high SB) and "physical inactivity" (i.e., low PAL) are frequently used interchangeably as synonyms (Forero, Morales, & Forero, 2023). Naturally, sedentary people spend more time in sedentary activities (i.e., watching TV, reading, playing video games, reading), which results in less time available to be physically active. Additionally, there is no doubt that sedentarism negatively influences physical capacity by decreasing muscular and functional capacities (i.e., fitness), which is another reason why people with high SB have lower PAL, simply because proper fitness allows one to be physically active at first place. As a result, a negative correlation between PAL and SB could be (naturally) expected.

On the other hand, modern life is often saturated with more or less mandatory sedentary activities. If we focus solely on children, at the very beginning of the mandatory school education (starting from six or seven years, depending on country), they are obligated to dedicate 5-6 hours of sedentarism during direct or indirect schooling (Tremblay et al., 2011). If we add the necessity of transport to different activities (including sports), SB increases to 7-8 hours daily. Furthermore, children often socialize through sedentary activities (mostly screen time), resulting in up to 9-10 hours of SB in regular circumstances. It is also common for parentally guided children to be involved in other forms of education (i.e., language, music), which additionally increases SB. Notably, children who have "increased SB" due to music or foreign-language education are often the same children who are engaged in out-of-school sport activities. While PAL exponentially increases as a result of sport participation lasting (for example) six hours per week, the duration of SB increases very much because of the other activities that are regular in preadolescence. Taken together, these results revealed small and nonsignificant correlations not only between SB and PAL but also between SB and PL. Therefore, a clear distinction should be made between "sedentary behavior" and "sedentary lifestyle (sedentarism)".

Limitations and strengths

The most important limitation of this study is that PAL was evaluated by questionnaire and not directly measured. Therefore, further analyses including direct measurements of the PAL at this age are needed. Next, this is a cross-sectional analysis, and consequently, causality cannot be explicitly identified. In future intervention studies, clear cause–effect relationships should therefore be evaluated.

This is one of the first studies in which the associations between PAL, SB and PL were evaluated via a sex-specific approach. This approach allowed specific and clear interpretations of the identified associations and provided directions for further studies in the field. Additionally, while PAL, PL and SB should be specifically investigated in different regions and under different sociocultural circumstances, this is one of the first investigations on a problem performed in southeastern Europe (e.g., the territory of former Yugoslavia).

Conclusion

The results clearly supported the necessity of a sex-stratified approach for evaluating associations between PL and PAL in preadolescence. Namely, the evaluation of the PL is based on comparisons with peers and friends, which is in this age group that is defined by sex/gender.

The greater correlation between PL and PAL in girls than in boys is probably influenced by differences in PA participation between boys and girls. While boys in preadolescence frequently participate in nonstructured activities, girls' PA is almost exclusively defined by participation in structured PA. Consequently, PA among girls is naturally followed by higher PL to a greater extent than among boys.

Although this is one of the first studies in which the correlation between SB and PAL was evaluated in preadolescents, it seems that SB and PAL are poorly correlated in this period of life. Most likely, the time spent in schooling and other educational activities increases sedentary time for all children, despite their PAL, leading to a lack of correlation between PAL and SB.

References

Alvarez-Pitti, J., Mallen, J. A. C., Trabazo, R. L., Lucia, A., de Lara, D. L., Aznar, L. A. M., & Martinez, G. R. (2020). Exercise as medicine in chronic diseases during childhood and adolescence. *Anales De Pediatria, 92*(3). doi:10.1016/j.anpedi.2020.01.010

Ariza, C., Sanchez-Martinez, F., Serral, G., Valmayor, S., Juarez, O., Pasarin, M. I., . . . & Grp, P. P. E. (2019). The Incidence of Obesity, Assessed as Adiposity, Is Reduced After 1 Year in Primary Schoolchildren by the POIBA Intervention. *Journal of Nutrition, 149*(2), 258-269. doi:10.1093/jn/nxy259

Belanger, K., Barnes, J. D., Longmuir, P. E., Anderson, K. D., Bruner, B., Copeland, J. L., . . . & Tremblay, M. S. (2018). The relationship between physical literacy scores and adherence to Canadian physical activity and sedentary behavior guidelines. *BMC Public Health, 18*. doi:ARTN 104210.1186/s12889-018-5897-4

Bremer, E., Graham, J. D., Bedard, C., Rodriguez, C., Kriellaars, D., & Cairney, J. (2020). The Association between PLAYfun and Physical Activity: A Convergent Validation Study. *Research Quarterly for Exercise and Sport, 91*(2), 179-187. doi:10.1080/02701367.2019.1652723

Cairney, J., Clark, H. J., James, M. E., Mitchell, D., Dudley, D. A., & Kriellaars, D. (2018). The Preschool Physical Literacy Assessment Tool: Testing a New Physical Literacy Tool for the Early Years. *Frontiers in Pediatrics, 6*. doi:10.3389/fped.2018.00138

Caldwell, H. A. T., Di Cristofaro, N. A., Cairney, J., Bray, S. R., MacDonald, M. J., & Timmons, B. W. (2020). Physical Literacy, Physical Activity, and Health Indicators in School-Age Children. *International Journal of Environmental Research and Public Health, 17*(15). doi:10.3390/ijerph17155367

Choi, S. M., Sum, R. K. W., Leung, E. F. L., & Ng, R. S. K. (2018). Relationship between perceived physical literacy and physical activity levels among Hong Kong adolescents. *Plos One, 13*(8). doi:ARTN e020310510.1371/journal.pone.0203105

Crocker, P., Bailey, D. A., Faulkner, R. A., Kowalski, K. C., & McGrath, R. (1997). Measuring general levels of physical activity: preliminary evidence for the Physical Activity Questionnaire for Older Children. *Medicine and Science in Sports and Exercise, 29*(10), 1344-1349.

de Andrade Leão, O. A., dos Santos, T. S., & da Silva, M. C. (2018). Correlation between physical activity and sedentary behavior in students. *Revista Brasileira em Promoção da Saúde, 31*(2). https://doi.org/10.5020/18061230.2018.7200

Farooq, A., Martin, A., Janssen, X., Wilson, M. G., Gibson, A. M., Hughes, A., & Reilly, J. J. (2020). Longitudinal changes in moderate-to-vigorous-intensity physical activity in children and adolescents: A systematic review and meta-analysis. *Obesity Reviews, 21*(1). doi:10.1111/obr.12953

Forero, A. Y., Morales, G. E., & Forero, L. C. (2023). Relationship between physical activity, sedentarism and obesity in adults, Colombia, 2015. *Biomedica, 43*(Sp. 3), 99-109. doi:10.7705/biomedica.7014

Geets-Kesić, M., Maras, N., & Gilić, B. (2023). Analysis of the Association Between Health Literacy, Physical Literacy, and Scholastic Achievement; A Preliminary Cross-Sectional Study Among High-School Students From Southern Croatia. *Montenegrin Journal of Sports Science & Medicine, 12*(1). https://doi.org/10.26773/mjssm.230301

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2020). Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1·6 million participants. *The Lancet Child & Adolescent Health, 4*(1), 23-35. https://doi.org/10.1016/S2352-4642(19)30323-2

Jean de Dieu, H., & Zhou, K. (2021). Physical literacy assessment tools: a systematic literature review for why, what, who, and how. *International Journal of Environmental Research and Public Health, 18*(15), 7954. https://doi.org/10.3390/ijerph18157954

Kuna, D., Duvnjak, I., & Sklempe Kokić, I. (2023). Levels of distress and physical activity of adolescents during the COVID-19 pandemic. *Sport Mont, 21*(1), 79-85. https://doi.org/10.26773/smj.230213

Longmuir, P. E., & Tremblay, M. S. (2016). Top 10 Research Questions Related to Physical Literacy. *Research Quarterly for Exercise and Sport, 87*(1), 28-35. doi:10.1080/02701367.2016.1124671

Maric, D., Kvesic, I., Lujan, I. K., Bianco, A., Zenic, N., Separovic, V., . . . & Sekulic, D. (2020). Parental and familial factors influencing physical activity levels in early adolescence: a prospective study. *Healthcare, 8*(4), 532. https://doi.org/10.3390/healthcare8040532

Pearson, N., Braithwaite, R. E., Biddle, S. J., van Sluijs, E. M., & Atkin, A. J. (2014). Associations between sedentary behavior and physical activity in children and adolescents: a meta-analysis. *Obesity Reviews, 15*(8), 666-675. doi:10.1111/obr.12188

Portela-Pino, I., Lopez-Castedo, A., Martinez-Patino, M. J., Valverde-Esteve, T., & Dominguez-Alonso, J. (2019). Gender Differences in Motivation and Barriers for The Practice of Physical Exercise in Adolescence. *International Journal of Environmental Research and Public Health, 17*(1). doi:10.3390/ijerph17010168

Rajkovic Vuletic, P., Gilic, B., Zenic, N., Pavlinovic, V., Kesic, M. G., Idrizovic, K., . . . & Sekulic, D. (2024). Analyzing the Associations between Facets of Physical Literacy, Physical Fitness, and Physical Activity Levels: Gender-and Age-Specific Cross-Sectional Study in Preadolescent Children. *Education Sciences, 14*(4), 391. https://doi.org/10.3390/educsci14040391

Samaržija, D. V., & Mišigoj-Duraković, M. (2013). Pouzdanost hrvatske verzije upitnika za procjenu ukupne razine tjelesne aktivnosti djece mlađe školske dobi [Reliability of the Croatian version of the questionnaire for assessing the overall level of physical activity of children of younger school age]. *Hrvatski športskomedicinski vjesnik, 28*(1), 24-32.

Stearns, J. A., Wohlers, B., McHugh, T. L. F., Kuzik, N., & Spence, J. C. (2019). Reliability and Validity of the PLAY. *Measurement in Physical Education and Exercise Science, 23*(1), 47-57. https://doi.org/10.1080/1091367X.2018.1500368

Tool with Children and Youth in Northern Canada. *Measurement in Physical Education and Exercise Science, 23*(1), 47-57. doi:10.1080/1091367x.2018.1500368

Štefan, L., Horvatin, M., & Baić, M. (2019). Are sedentary behaviors associated with sleep duration? A cross-sectional case from Croatia. *International Journal of Environmental Research and Public Health, 16*(2), 200. https://doi.org/10.3390/ijerph16020200

Sunda, M., Gilic, B., Sekulic, D., Matic, R., Drid, P., Alexe, D. I., . . . & Lupu, G. S. (2022). Out-of-School Sports Participation Is Positively Associated with Physical Literacy, but What about Physical Education? A Cross-Sectional Gender-Stratified Analysis during the COVID-19 Pandemic among High-School Adolescents. *Children (Basel), 9*(5). doi:10.3390/children9050753

Tremblay, M. S., LeBlanc, A. G., Kho, M. E., Saunders, T. J., Larouche, R., Colley, R. C., . . . & Gorber, S. C. (2011). Systematic review of sedentary behavior and health indicators in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity, 8*, 1-22.

Veitch, J., Salmon, J., & Ball, K. (2010). Individual, social and physical environmental correlates of children's active free-play: a cross-sectional study. *International Journal of Behavioral Nutrition and Physical Activity, 7*, 1-10.

Vukelja, M., Milanovic, D., & Salaj, S. (2022). Physical activity and sedentary behavior in croatian preschool children: a population-based study. *Montenegrin Journal of Sports Science & Medicine, 11*(1). https://doi.org/10.26773/mjssm.220304

Vuletic, P. R., Kesic, M. G., Gilic, B., Pehar, M., Uzicanin, E., Idrizovic, K., & Sekulic, D. (2023). Evaluation of Physical Literacy in 9- to 11-Year-Old Children: Reliability and Validity of Two Measurement Tools in Three Southeastern European Countries. *Children (Basel), 10*(11). doi:10.3390/children10111722

Whitehead, M. (2013). Definition of physical literacy and clarification of related issues. *Icsspe Bulletin, 65*(1.2).