



Exploring the Link Between Health Literacy, Physical Literacy, and Fitness in Late Adolescence: A Gender-Stratified Cross-Sectional Study

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Abstract

Health literacy (HL) and physical literacy (PL) are important concepts of healthy lifestyles, but there is an evident lack of knowledge on the possible associations between HL and PL, with physical fitness (PF) as an indicator of overall health status. This study aimed to evaluate the associations between HL and PL and various indices of PF in high school adolescents. The participants were 196 high school adolescents (92 females, 17.32 ± 1.02 years of age) who were tested on PL, HL and PF. PL was evaluated by the Physical Literacy Assessment of Youth (PLAYself) and Canadian Physical Literacy Assessment questionnaire knowledge and understanding (CAPL-2-KU), while HL was evaluated by the European Health Literacy Survey Questionnaire 47. Apart from anthropometric/body composition indices (body height, body mass, body mass index, body fat and skeletal muscle mass), PF variables included broad jump, sit-ups, bent-arm-hang, sit-and-reach test and pacer test. Significant gender differences were observed in several PF measures and in CAPL-2-KU, with girls achieving higher CAPL-2-KU scores than boys, whereas no significant gender differences were found in HL or overall PLAYself. HL was not correlated with PF indices in the total sample or when stratified by gender. Overall PLAYself was positively correlated with all PF indices in boys ($r = 0.29-0.41$, $p < 0.01$) and with sit-ups and pacer performance in girls ($r = 0.29-0.34$, $p < 0.01$), whereas CAPL-2-KU was not significantly associated with PF. The lack of associations between HL and PF suggests that health-related knowledge alone may not translate into higher fitness levels during adolescence and that behavioral or contextual factors may contribute to this relationship. The contrasting associations observed for PLAYself and CAPL-2-KU suggest that self-perceived PL and the knowledge and understanding domain may relate differently to PF in late adolescence.

Keywords: Physical Education, High School, Students, Lifestyle, Recreation



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Introduction

Adolescence is a developmental period characterized by significant physical, cognitive, and emotional changes (Scott & Saginak, 2016). Therefore, establishing a good base for health behaviors during this phase is crucial for lifelong well-being. One of the most important health behaviors is engaging in sufficient physical activity (PA). Indeed, regular PA is linked to a variety of health advantages, including a lower risk of chronic illnesses, greater mental health, greater cognitive function, and improved academic achievement (Warburton & Bredin, 2017). Notably, achieving higher physical activity levels (PALs) is significantly linked to physical fitness, which is one of the main determinants of health status.

Physical fitness (PF), which is typically defined as the capacity to complete daily chores with vigor and without becoming exhausted, is a key predictor of adolescent health (Marttinen et al., 2021; Strong et al., 2005). Studies have demonstrated that youth who engage in more PA (having a higher PAL) have better PF profiles, such as lower body fat percentages and improved cardiorespiratory and muscular fitness (Gisladdottir et al., 2023; Neil-Sztramko et al., 2021; Ortega et al., 2008). Furthermore, consistent PA during adolescence provides the framework for adult PF, improving long-term health and well-being (Salam et al., 2016). However, as the prevalence of physical inactivity among adolescents is a global issue, it also affects PF and overall health status. Therefore, there is a growing amount of research regarding various concepts that are forming a background for attaining positive health behaviors in adolescents.

One of the emerging concepts for attaining health behaviors that emphasize PA is physical literacy (PL), which includes the skills, knowledge, and attitudes required for participating in PA. The most commonly used definition of PL is that it is the “drive, confidence, physical competence, knowledge, and understanding to appreciate and accept responsibility for participating in PA throughout life (Edwards et al., 2017).” PL serves to lay the groundwork for lifetime healthy behaviors in youth by instilling a good attitude toward PA and providing them with essential skills (Durdin-Myers et al., 2018). Importantly, adolescents with better PAs are more likely to participate in a variety of PAs, which improves their PF and general health (Tremblay et al., 2018). Indeed, a recent study that investigated the associations between PL and PF indices, which included lower and upper-body muscular strength, revealed that PL was linked to increased muscular fitness among Spanish adolescents (Villa-González et al., 2024). Similarly, a Croatian study reported that adolescents with higher PLs had better cardiovascular endurance, jumping capacity, flexibility and abdominal muscle strength, all of which are indices of PF (Gilic et al., 2022). This relationship has recently been confirmed by a systematic review and meta-analysis including more than 43,000 children and adolescents, which demonstrated positive associations between overall PL and cardiorespiratory fitness, as well as between individual PL domains and cardiorespiratory fitness (Jiang et al., 2025).

Another emerging concept linked to health behaviors is health literacy. Health literacy (HL), defined as the ability to access, understand, appraise, and apply health information to make informed health decisions, is essential for managing health effectively (Liu et al., 2020). Higher HL contributes to

better health outcomes by enabling individuals to navigate health services, understand medical instructions, and adopt healthier lifestyles (Sørensen et al., 2012). Adolescents with higher HL are better equipped to make informed decisions about their PA and overall health, fostering a virtuous cycle of health-promoting behaviors (Nutbeam, 2008). Understanding the benefits of regular PA, for example, might encourage youth to participate in PA that enhances their cardiovascular health, muscle strength, and general physical endurance (Paakkari & Okan, 2020). In one systematic review regarding associations between HL and PA, the majority of studies reported a substantial positive association between high HL and high levels of PA (Buja et al., 2020). Consequently, it could be theorized that HL will also be positively correlated with PF. However, studies have mainly investigated associations between PL and PF, while there is a lack of studies that have directly investigated the associations between HL and PF in adolescents.

Despite the recognized importance of PF, PL, and HL, research examining their interconnections in adolescents is limited. This study aimed to examine the associations between HL and PF, as well as between PL and PF, among adolescents. In other words, we tried to determine how the levels of HL and PL impact adolescents' PF status, shedding light on the linked aspects that contribute to overall health and well-being at this key developmental stage. This study seeks to fill this gap by investigating how these three components interact with and contribute to the health and well-being of Croatian adolescents. Understanding these relationships can inform the development of targeted interventions aimed at improving adolescent health outcomes. Initially, we hypothesized that (i) HL will be positively correlated with PF and that (ii) PL will be positively correlated with PF in the adolescents studied.

Materials and methods

Participants

The participants were 196 high school adolescents (92 females) aged 16–19 years (17.32 ± 1.01 years). All participants were regularly attending PE classes and were in good health. The exclusion criterion was any mental or physical illness or disability. Parents or legal guardians signed informed consent for underage participants before the start of the study. The ethical board of the Faculty of Kinesiology, University of Split, approved the study.

Variables and procedures

The variables in the study consisted of health literacy and physical literacy questionnaires, anthropometric/body composition indices (body mass, body height, body mass index, and body fat percentage), and physical fitness tests.

Body height was measured in centimeters using the altimeter, with participants standing barefoot on a flat and firm surface in an upright position. Body mass (in 0.1 kg), body fat percentage (%) and skeletal muscle mass percentage (%) were measured with a digital diagnostic scale (Tanita BC 418 scale; serial number 15010067, 2015). The measurement was performed with the participant standing barefoot and upright on the scale and wearing a sports shirt and shorts. Body mass index (BMI) was calculated as the ratio of body mass (in kg) to squared body height (in meters).

The translated version in the Croatian language of the European Health Literacy Survey Questionnaire 47 (HLS-

EU-Q47) was used to measure HL since it has previously been shown to be valid in Croatian adolescents (Geets-Kesić, 2024). The reliability of the HLSEU questionnaire was high with Kappa coefficients of 0.79, and 91% equally responded answers (Geets Kesić et al., 2022). The questionnaire includes 47 questions on an individual's capacity to collect, process, and understand fundamental health information and services, enabling them to make informed health decisions. A 4-point Likert scale ranging from 1 (extremely difficult) to 4 (very easy) was used to create an overall indicator of HL. The score was determined using the originally developed formula: $\text{index} = (\text{mean} - 1) \times (50/3)$. Scoring was based on a scale of 0-50, with 0 being the lowest and 50 being the highest (Sørensen et al., 2015).

The Physical Literacy Assessment of Youth (PLAYself) and the Canadian Physical Literacy Assessment questionnaire knowledge and understanding (CAPL-KU) were used for assessing PL. The PLAYself scale has five subscales: (i) affective and cognitive; (ii) environment; (iii) literacy, (iv) numeracy, and (v) PL in various situations. The results of the subdomains are calculated by summing all responses scored from 0-100 and dividing them by the number of questions. The overall result of the questionnaire is calculated by summing the points from the subdomains and dividing by the total number of questions (27 in total). The maximum self-perceived PL is achieved with a total score of 100, including subscales. The CAPL-2-KU included 12 questions on the advantages of physical exercise, cardiorespiratory endurance, fitness state, muscular strength, and daily physical activity guidelines. Each question included four options, with right answers evaluated as 1 and erroneous answers evaluated as 0. The questionnaire allows a maximum score of 12 points. Both questionnaires were previously validated in Croatian adolescents (Gilic et al., 2022). SurveyMonkey (SurveyMonkey Inc., San Mateo, CA, USA) was used to administer all the surveys, including the HLS-EU-Q47 and PLAYself.

The physical fitness tests included the broad jump test, sit-ups, bent-arm-hang test, sit-and-reach test and pacer test, all part of the standard testing procedures during the PE curricula (Mraković et al., 1996). PE teachers, who are competent assessors, administered all tests.

A broad jump was used to assess jumping capacity. The test was conducted in a gym on the jumping mat and from a standing posture. Participants were given instructions to begin the jump with bent knees and swing their arms for assistance. The test was repeated three times approximately 30 seconds apart, and the best score (in cm) was considered the final achievement.

The number of sit-ups was measured to assess abdominal muscle strength. The test was performed with hands locked behind the head and legs bent below 90 degrees and feet fixed under the Swedish ladders. The result consisted of a number of correct repetitions completed within a minute.

A bent-arm hang (BAH) was used to assess static upper-body strength. The test was conducted in a gymnasium during a single trial. Participants were assisted in performing one underhang pull-up on a regular horizontal bar. Participants were required to maintain a maximum bent position (chin over the bar) for a maximum period of time, and the result was expressed in seconds.

The sit-and-reach test was used to assess lower-body and lower-back flexibility. The test was conducted with participants sitting on the floor with their backs against the wall and

legs spread apart at 45 degrees. The participants had to bend forward as far as possible with extended arms, and the maximal point reached and was maintained for 3 seconds. There were three trials, and the best result was used as a final score expressed in centimeters.

The pacer test, as a measure of cardiorespiratory endurance, included running continuously between two points that were 20 meters apart. Runs of 20 meters were timed to a prerecorded sound signal that beeped at predetermined intervals; two consecutive beeps were separated by 9 seconds at the start of the test, and as it went on, the interval between beeps decreased (with an increase in tempo of approximately 10% per minute). As a result, participants had to increase their running speed throughout the course. The test was concluded when participants were unable to keep up with the sound signal; specifically, one missed lap was permitted, the second missed lap was the end of the test, and the final result was the level reached for each participant (Léger et al., 1988).

Statistical analysis

Variables were checked for normality of distributions by the Kolmogorov-Smirnov test, and descriptive statistics comprised calculations of means and standard deviations for all study variables. Since variables were normally distributed, we used parametric statistical tests.

Differences between genders were established by t-tests for independent samples.

Associations between variables were checked by calculating Pearson's correlations, which were performed for the total sample and stratified by gender. The magnitudes of Pearson's correlation coefficient are interpreted as follows: small (weak) correlation is between 0.10 and 0.29, medium (moderate) correlation is between 0.30 and 0.49, and large (strong) correlation is 0.50 or above (Cohen, 1988). Statistica ver 13.5 (Tibco Inc. Palo Alto CA, USA) was used for all calculations and p-level of 0.05 was applied.

Results

Table 1 presents descriptive statistics and differences between boys and girls in terms of the study variables. With regard to body composition and anthropometric data, boys were taller and heavier and had greater muscle mass than girls did (t-test = 15.97, 7.82, and 9.62; all $p < 0.001$), while girls had greater fat mass than boys did (t-test = 9.17, $p < 0.001$). Considering fitness variables, boys achieved better results in broad jump (t-test = 10.48, $p < 0.001$), sit-up (t-test = 6.33, $p < 0.001$), bent arm hang (t-test = 8.01, $p < 0.001$), and pacer tests of cardiovascular endurance (t-test = 16.00, $p < 0.001$). However, girls achieved significantly higher CAPL-2-KU scores than boys. No significant differences were found in HL between boys and girls.

The correlation analyses for the total sample are presented in Table 2. HL was not significantly associated with any PF variable, although a weak negative correlation was found with BMI. Overall PLAYself score was positively associated with broad jump, sit-and-reach, sit-ups, bent-arm-hang, and pacer performance, with correlations ranging from $r = 0.21$ to 0.33. Among the PLAYself subdomains, the strongest and most consistent positive associations with PF were observed for Play-self-1 and Play-self-2. In contrast, CAPL-2-KU was not significantly correlated with any PF or anthropometric/body composition variable in the total sample.

Table 1. Descriptive statistics and differences between boys and girls in study variables

	Girls		Boys		t-test	
	Mean	SD	Mean	SD	t-value	p
Health literacy (score)	33.56	7.20	33.33	6.53	0.25	0.80
Play-self-1 (score)	299.36	93.11	313.76	120.88	-1.01	0.31
Play-self-2 (score)	763.90	174.98	832.06	198.31	-2.75	0.01
Play-self-3 (score)	229.41	53.72	198.37	76.27	3.57	0.001
Play-self-4 (score)	187.06	63.93	163.08	76.63	2.57	0.01
Play-self-5 (score)	242.91	55.23	241.82	60.17	0.14	0.89
Play-self total (score)	63.80	11.16	64.78	13.37	-0.60	0.55
CAPL-2-KU (score)	7.98	1.85	7.04	2.51	3.25	0.01
Body height (cm)	168.83	5.98	182.56	6.18	-15.97	0.001
Body mass (kg)	60.44	10.66	73.87	13.51	-7.82	0.001
Body mass index	21.18	3.46	22.17	3.54	-1.02	0.31
Fat mass (%)	24.25	6.55	15.47	6.97	9.17	0.001
Skeletal muscle mass (%)	41.85	4.64	47.47	3.52	-9.62	0.001
Broad jump (cm)	172.33	18.07	208.94	31.06	-10.48	0.001
Sit-and-reach (cm)	84.02	11.52	84.22	14.89	-0.11	0.91
Sit-ups (rep)	46.07	9.02	53.93	9.03	-6.33	0.001
Bent-arm-hang (s)	19.89	15.59	40.34	21.05	-8.01	0.001
Pacer test (level)	5.15	1.25	8.23	1.56	-16.00	0.001

Legend: Play-self-1 – environment subdomain of the PLAYself questionnaire; Play-self-2 – self-description subdomain of the PLAYself questionnaire; Play-self-3 – literacy subdomain of the PLAYself questionnaire; Play-self-4 – numeracy subdomain of the PLAYself questionnaire; Play-self-5 – physical literacy subdomain of the PLAYself questionnaire; CAPL-2-KU – Canadian Assessment of Physical Literacy, Second Edition – Knowledge and Understanding domain

Table 2. Pearson's correlations between study variables for total sample of participants (n = 196)

	Health literacy	Play-self-1	Play-self-2	Play-self-3	Play-self-4	Play-self-5	Play-self total	CAPL-2-KU
Broad jump	-0.01	0.27***	0.33***	-0.14	-0.09	0.03	0.24***	-0.07
Sit-and-reach	-0.01	0.20**	0.30***	-0.12	-0.04	0.03	0.21**	0.02
Sit-ups	0.04	0.28***	0.41***	-0.09	-0.01	0.16*	0.33***	-0.08
Bent-arm-hang	0.01	0.25***	0.39***	-0.05	-0.11	0.09	0.29***	-0.06
Pacer	0.07	0.21**	0.41***	-0.14	-0.10	0.11	0.28***	-0.07
Body height	0.05	0.03	0.16*	-0.15*	0.01	0.01	0.07	-0.12
Body mass	0.05	0.09	0.10	-0.05	0.05	0.00	0.09	-0.06
Body mass index	-0.16*	-0.09	-0.04	-0.06	0.03	-0.02	-0.06	-0.01
Fat mass	0.05	-0.05	-0.15*	0.12	0.09	-0.01	-0.06	0.09
Skeletal muscle mass	0.01	0.06	0.14	-0.15*	-0.11	-0.02	0.05	-0.12

Legend: Play-self-1 – environment subdomain of the PLAYself questionnaire; Play-self-2 – self-description subdomain of the PLAYself questionnaire; Play-self-3 – literacy subdomain of the PLAYself questionnaire; Play-self-4 – numeracy subdomain of the PLAYself questionnaire; Play-self-5 – physical literacy subdomain of the PLAYself questionnaire; CAPL-2-KU – Canadian Assessment of Physical Literacy, Second Edition – Knowledge and Understanding domain; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; light grey color indicates low magnitude of correlation; darker grey color indicates moderate magnitude of correlation

The correlations for boys are presented in Table 3. HL was not significantly associated with PF variables, although a weak negative correlation was observed with BMI ($r = -0.23$, $p < 0.05$). Overall PLAYself score was positively correlated with all PF measures, including broad jump ($r = 0.30$), sit-and-reach ($r = 0.29$), sit-ups ($r = 0.41$), bent-arm-hang ($r = 0.40$), and pacer performance ($r = 0.40$). Several PLAYself subdomains, particularly Play-self-1 and Play-self-2, were also positively associated with PF. In contrast, CAPL-2-KU was not significantly correlated with any PF or anthropometric/body composition variable among boys.

The correlations between the study variables for girls are presented in Table 4. HL was not significantly correlated with any of the PF variables. Moreover, PLAYself score was positively associated with sit-ups ($r = 0.29$, $p < 0.01$) and pacer performance ($r = 0.34$, $p < 0.001$), whereas no significant associations were observed with broad jump, sit-and-reach, or bent-arm-hang. Several individual PLAYself subdomains were also associated with selected PF and anthropometric measures. In contrast, CAPL-2-KU was not significantly associated with any PF, anthropometric, or body composition variable among girls.

Table 3. Pearson's correlations between study variables for boys (n = 102)

	Health literacy	Play-self-1	Play-self-2	Play-self-3	Play-self-4	Play-self-5	Play-self total	CAPL-2-KU
Broad jump	0.02	0.37***	0.35***	-0.10	-0.04	0.07	0.30**	0.10
Sit-and-reach	-0.04	0.25**	0.38***	-0.02	-0.09	0.11	0.29**	0.01
Sit-ups	0.03	0.39***	0.49***	-0.04	-0.04	0.21*	0.41***	0.04
Bent-arm-hang	0.13	0.31**	0.50***	0.03	-0.05	0.19*	0.40***	0.03
Pacer	0.12	0.29**	0.48***	-0.02	-0.01	0.25***	0.40***	0.14
Body height	0.06	-0.09	-0.05	0.08	0.22**	0.13	0.03	0.07
Body mass	-0.02	-0.03	-0.08	0.07	0.13	0.07	0.00	0.08
Body mass index	-0.23*	-0.13	-0.07	-0.05	0.05	-0.02	-0.09	0.06
Fat mass	-0.07	-0.07	-0.15	0.08	0.04	-0.06	-0.09	0.05
Skeletal muscle mass	0.15	0.16	0.28**	-0.09	-0.06	0.08	0.19	-0.04

Legend: Play-self-1 – environment subdomain of the PLAYself questionnaire; Play-self-2 – self-description subdomain of the PLAYself questionnaire; Play-self-3 – literacy subdomain of the PLAYself questionnaire; Play-self-4 – numeracy subdomain of the PLAYself questionnaire; Play-self-5 – physical literacy subdomain of the PLAYself questionnaire; CAPL-2-KU – Canadian Assessment of Physical Literacy, Second Edition – Knowledge and Understanding domain; * p < 0.05; ** p < 0.01; *** p < 0.001; light grey color indicates low magnitude of correlation; darker grey color indicates moderate magnitude of correlation

Table 4. Pearson's correlations between study variables for girls (n = 96)

	Health literacy	Play-self-1	Play-self-2	Play-self-3	Play-self-4	Play-self-5	Play-self total	CAPL-2-KU
Brad jump	-0.02	0.13	0.19	0.13	-0.01	0.10	0.19	-0.07
Sit-and-reach	0.02	0.13	0.18	-0.30**	0.06	-0.09	0.09	0.05
Sit-ups	0.06	0.19	0.27**	0.04	0.14	0.20	0.29**	-0.06
Bent-arm-hang	-0.11	0.18	0.12	0.10	-0.07	0.06	0.14	0.05
Pacer	0.13	0.23*	0.38***	0.09	-0.02	0.22*	0.34***	0.10
Body height	0.13	0.06	0.14	-0.09	0.05	0.02	0.10	-0.03
Body mass	0.20	0.22*	0.14	0.05	0.15	-0.02	0.19	-0.02
Body mass index	0.16	0.21*	0.08	0.08	0.12	-0.04	0.15	-0.01
Fat mass	0.18	0.04	0.04	-0.06	0.03	-0.02	0.03	-0.10
Skeletal muscle mass	-0.08	-0.08	-0.13	-0.01	-0.04	-0.05	-0.12	0.01

Legend: Play-self-1 – environment subdomain of the PLAYself questionnaire; Play-self-2 – self-description subdomain of the PLAYself questionnaire; Play-self-3 – literacy subdomain of the PLAYself questionnaire; Play-self-4 – numeracy subdomain of the PLAYself questionnaire; Play-self-5 – physical literacy subdomain of the PLAYself questionnaire; CAPL-2-KU – Canadian Assessment of Physical Literacy, Second Edition – Knowledge and Understanding domain; * p < 0.05; ** p < 0.01; *** p < 0.001; light grey color indicates low magnitude of correlation

Discussion

Our results revealed several important findings. First, HL was not significantly associated with PF in either boys or girls. Second, the associations between PL and PF differed depending on the PL measure used. Overall, PLAYself was positively associated with all PF indices among boys, whereas among girls significant associations were observed only with sit-ups and pacer performance. In contrast, CAPL-2-KU was not significantly associated with any PF measure in either gender. Finally, girls achieved significantly higher CAPL-2-KU scores than boys, despite generally poorer performance in most PF tests. Therefore, our first hypothesis was rejected, whereas the second hypothesis was only partially supported and appeared to apply to self-perceived PL rather than to the knowledge and understanding domain of PL.

Lack of correlation between health literacy and physical fitness

The finding that HL was not intercorrelated with PF in boys and girls suggests that an individual's knowledge and understanding of health information does not necessarily translate into higher levels of PF. Interestingly, recent evidence supports this interpretation by suggesting that the relation-

ship between HL and PF may not be direct. Namely, a Slovak study showed that HL in adolescents was directly associated with PA, whereas its associations with cardiorespiratory fitness and body composition were primarily mediated by PA (Hnidková et al., 2024). Therefore, higher HL may facilitate healthier behavioral choices, but these behaviors need to be translated into regular PA before measurable differences in PF become evident. Furthermore, this disconnection could be due to a variety of factors, including the availability of resources, personal motivation, socioeconomic conditions, and the effectiveness of health education programs.

Namely, even while adolescents comprehend the benefits of PA, they may lack the will to put their knowledge of health into practice. Also, adolescents may experience numerous challenges in using their health knowledge, including socioeconomic restraints or insufficient support from family and friends. For example, families with lesser incomes may find it difficult to provide their children with extracurricular activities or nutritional food. Finally, there are differences in the effectiveness and quality of health education programs, so although teenagers may learn health-related information, they might not have the skills to put it into practice, especially if

they are dealing with issues like peer pressure or inadequate family support. Adolescents' PA levels are also heavily influenced by their motivating factors and personal interests. Even with basic health knowledge, inadequate intrinsic drive to engage in PA may prevent the improvement of PF (Paakkari & Paakkari, 2012). These findings emphasize the importance of multidimensional health promotion programs that target not only HL but also environmental, social, and motivational aspects to successfully improve PF in adolescents.

A weak association was established between HL and BMI in boys. Supportively, a study on adolescents reported a correlation between HL and obesity, with lower HL indicating a greater likelihood of obesity (Sharif & Blank, 2010). Additionally, a study on 1035 adolescents aged 12-19 years revealed a strong association between low HL and overweight/obesity (Chari et al., 2014). However, the correlation between BMI and HL was not strong in our study, suggesting that boys with higher HL may have a slightly better understanding of healthy body weight management. Indeed, it was proven that adolescents with low HL tend to consume more sugar, fat, and salt, resulting in increased weight, BMI, and body fat percentage (Buja et al., 2021; Klinker et al., 2020). This could reflect a modest impact of health knowledge (i.e., HL) on lifestyle choices that affect BMI, such as diet and PA levels. However, the weak nature of this association indicates that other factors are likely more influential in determining BMI.

The relationships between HL and BMI in boys but not in girls should further be discussed in light of gender differences in HL and BMI. Specifically, boys may encounter more pressure to meet fitness norms, leading them to use health information to efficiently control their weight (Zhang et al., 2019). In other words, boys may be more likely to provide health information through healthier food choices and increased exercise, resulting in greater direct effects on BMI. On the other hand, girls' BMI may be altered by body image concerns and hormonal changes during adolescence, regardless of their HL (Lovrić et al., 2022). Namely, hormonal changes related to puberty can significantly impact body composition and fat distribution (Roemmich & Rogol, 1999). These biological changes can lead to fluctuations in weight and BMI that are not necessarily reflective of lifestyle or HL but rather the natural physiological progression during adolescence. Additionally, girls may feel additional pressure to comply with specific body image norms, which can lead to behaviors that are unrelated to HL, such as strict calorie restriction or excessive exercise (Meredith & Dwyer, 1991). Notably, boys and girls go through puberty differently, which can affect BMI in a variety of ways. For example, boys tend to gain muscular mass, while girls accumulate body fat (Wells, 2007), which may interact differently with HL.

Significant correlation between physical literacy and physical fitness in boys

Our results indicated significant associations between PLAYself and PF in boys, which is in accordance with previous studies in children and adolescents (Gilic et al., 2022; Hardy et al., 2014; Pastor-Cisneros et al., 2021). The first reason for the significant positive correlation between perceived PL and PF is that PL generally involves the development of fundamental movement skills such as running, jumping, throwing, and catching, and the evaluation of PL actually includes self-perceived competence in these skills. These skills are essential for

engaging in a variety of physical activities that consequently improve measures of PF by improving coordination, balance, and agility, leading to better PF in general (Hardy et al., 2014). Additionally, adolescents who are physically literate are more likely to engage in regular PA because they possess the skills and confidence to participate in different sports and exercises, which naturally contributes to (additional) development and maintenance of PF, including cardiovascular health, muscular strength, and flexibility (Nezondet et al., 2023). It is also important to note that PL encompasses not only physical skills but also cognitive and emotional aspects, such as motivation and confidence in one's abilities. Moreover, higher levels of motivation and confidence are known to be among the most important prerequisites of increased physical activity, which in turn enhances PF (K et al., 2014). This mechanism can be observed throughout the positive feedback loop (Hui, 2022). In other words, mastery of movement skills can create a positive feedback loop in which success in PA boosts confidence and enjoyment, leading to more frequent participation. This further improves fitness levels, reinforcing the cycle of PA and fitness.

Interestingly, the two PL measures showed distinctly different relationships with PF. While the overall PLAYself score was positively associated with several PF indices, CAPL-2-KU was not significantly associated with any PF measure in the total sample or in gender-stratified analyses. This discrepancy may reflect the different components of PL captured by the two instruments. PLAYself primarily reflects adolescents' self-perceptions of their physical competence and experiences across different movement contexts, whereas CAPL-2-KU specifically assesses knowledge and understanding related to physical activity and fitness (Gilic et al., 2022). Consequently, self-perceived competence may be more closely related to actual engagement in PA and accumulated movement experiences, and therefore to PF, than knowledge about physical activity itself.

Correlation between physical literacy and physical fitness in girls

While all PF indices were positively correlated among boys, only two PF measures were correlated with the PL among girls. In explaining these dissimilarities, it is important to highlight some specifics of different types of PAs and their (confirmed) influence on PF status. In brief, it is well known that not all types of PAs are equally beneficial for improving various PF indices. For example, while cardiovascular endurance could be developed by a variety of exercises (i.e., low-intensity PA of long duration, moderate-to-high intensity PA of shorter duration), some other aspects of PF can be developed only by specific types of exercise (Malina et al., 2004). Specifically, (only) PA of high intensity is effective in the development of power capacities, while low-intensity exercise will not have a positive effect on these PF attributes. Additionally, the development of strength capacities and flexibility are topologically defined, meaning that each body region should be trained using specific exercises (Strength & Association, 2021).

The previous discussion is important since studies have confirmed a positive correlation between PL and PAL, and while PAL is positively associated with PF, it could altogether imply that PL should be correlated with PF (Nezondet et al., 2023). In other words, (i) if a higher PL results in a higher PAL and (ii) a higher PAL is associated with better PF, (iii) a positive correlation between the PL and PF would also be

expected. However, it is well known that girls often exhibit low-intensity PA (Jago et al., 2005). While such activities could be beneficial for improving cardiovascular endurance, the development of other PF indices is not expected. Similarly, previous studies performed in the region reported that adolescent girls are less likely to be involved in sports than boys are, and even if they are involved, girls often participate in sports of relatively lower intensity than boys (i.e., different forms of dance sports) (Maric et al., 2020; Miljanovic Damjanovic et al., 2019). Consequently, a specific chain of reaction occurs. In brief, (i) participation in specific sports and PA of low intensity increases the PL among girls, but (ii) physically literate girls do not have a high level of (all) PF capacity, but only those PF indices that are directly influenced by the activities they participate in. As a result, (positive) correlations between PL and PF variables in girls are generally positive, but at the same time not so pronounced as in boys.

This interpretation is further supported by the gender differences observed in the present study. Girls achieved significantly higher CAPL-2-KU scores than boys despite demonstrating lower performance in most PF tests. Thus, greater knowledge and understanding of PA and fitness did not correspond to better PF. Taken together, these findings may indicate that cognitive knowledge alone has a weaker relationship with current PF than experiential and self-perceived aspects of PL. However, given the cross-sectional design, this interpretation should be considered exploratory and requires confirmation in future studies.

Limitations and strengths

The cross-sectional nature of the research is the most important limitation of this study. Therefore, while some relationships may be intuitively interpreted (i.e., negative correlations between body height and body fat and positive correlations between body height and some fitness capacities such as broad jump), the study design does not allow for the identification of cause–effect relationships. Therefore, prospective studies are needed to evaluate the studied interrelationships in more detail. Additionally, this study included participants from one urban center in Croatia; therefore, the generalizability of the findings is limited to similar samples only. Finally, a relatively large number of bivariate correlations were examined without adjustment for multiple comparisons. Therefore, particularly isolated associations of small magnitude should be interpreted cautiously and require confirmation in future studies.

All variables were collected by the same evaluators under the same conditions over a relatively narrow time span (up to 15 days at maximum). Therefore, the established correlations should be considered plausible. Additionally, the investigators involved in testing were experienced PE teachers who were involved in regular educational processes with the studied participants, which is an important strength of the study.

Conclusion

Despite the initial expectations, the results revealed no correlation between HL and PF in adolescents. Most likely, individual knowledge on health-related issues and understanding of health information do not translate into higher levels of PF due to a variety of factors, such as personal motives and sociocultural and economic conditions. However, this study included a specific sample of participants from one urban center; therefore, further analyses are needed to explore the prob-

lem in more detail.

Positive associations between self-perceived PL, assessed using PLAYself, and PF were more consistent among boys than girls, suggesting potential gender differences in the relationship between perceived PL and PF. In contrast, CAPL-2-KU was not associated with PF in either gender, despite girls demonstrating higher CAPL-2-KU scores than boys. These findings highlight that different components of PL may relate differently to PF, with self-perceived and experiential aspects appearing more closely associated with PF than the knowledge and understanding domain. Future longitudinal studies should examine how these distinct PL components interact with PA behavior and PF development during adolescence.

Informed Consent Statement

Written consent was obtained from parents of all subjects involved in the study.

Data Availability Statement

Data is available upon reasonable request.

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Conflicts of Interest

The authors declare no conflict of interest.

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