Cardiorespiratory Fitness and Physical Literacy: Exploring the Nexus. A Scoping Review

ABSTRACT

Background and Objectives: Physical literacy refers to a set of knowledge, skills and attitudes related to physical activity, while cardiorespiratory fitness is a crucial indicator of an individual's cardiovascular and pulmonary health. Understanding the interaction between these two concepts is crucial in the context of health promotion and physical education. Such understanding provides valuable information that can be used to develop policies and intervention programmers.

Materials and Methods: The study adopted a scoping review approach to explore and synthesize the existing scientific literature on the relationship between physical literacy and cardiorespiratory fitness. This methodological approach was selected due to its efficiency in quickly gathering and mapping relevant information, following the recommendations of the PRISMA standard for scoping reviews. A total of 10 research articles were reviewed in this process, encompassing methodologies ranging from cross-sectional and quasi-experimental to prospective studies.

Results: Preliminary findings from this research indicate that there is a dynamic and close interaction between physical literacy and cardiorespiratory fitness. This relationship highlights the holistic nature of physical literacy, whereby knowledge, skills, and attitudes related to physical activity are closely linked and intertwined with cardiorespiratory health.

Conclusion: This cycle generates positive outcomes, as physical literacy encourages and inspires individuals to engage in sustainable physical activity. This study aims to analyse the relationship between physical literacy and cardiorespiratory fitness.

Paper Type: A Scoping Review

Keywords: Physical Activity, Physical Literacy, Physical Fitness, Exercise Capacity, Cardiorespiratory Fitness.

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Introduction

Physical literacy (PL) refers to a set of personal skills and attributes that develop and demonstrate through movement and physical activity over the course of lifespan, regardless of a person's level of physical fitness (1). Physical literacy is a broad concept and encompasses several essential aspects like physical, emotional, motivational, affective, cognitive, and environmental conditions that influence and modify the physical activity lifestyle manifested throughout the lifespan. For ease of reference, these particular characteristics are explained below.

In the first instance, physical literacy covers an area that focuses on the motivation and confidence levels of individuals who participate in physical activity. The motivational-affective domain aims to understand the fundamental motivational factors that affect physical activity participation (1, 2). Moreover, PL includes a physical dimension, which assesses a person's competence to perform a variety of movements and activities effectively. This physical competence is essential for active participation in physical-sporting tasks that promote a healthier lifestyle (2, 3).

Furthermore, physical literacy encompasses not only cognitive, emotional, and physical aspects. A comprehensive understanding and awareness of the significance of physical activity is crucial for maintaining good health and well-being (3). Finally, physical literacy encompasses behavioral factors, which entail continuous engagement in physical activities. This is essential as promoting active participation leads to a healthy and active lifestyle with significant mental and physical benefits (4).

In recent years, interest in the concept of Physical Literacy (PL) and its assessment has grown in response to the challenges posed by the high prevalence of physical inactivity in society (5, 6) and the low statistical variability over time in meeting WHO recommendations (7).

Although engaging in physical activity is known to have health benefits and reduce the risk of cardiovascular diseases (8), cardiorespiratory fitness (CRF) is an independent factor that provides additional benefits. It operates through different physiological mechanisms and can further reduce the relative risk of death from all causes (9–11). However, it is necessary to examine the literature to see if PL is a better fit with CRF than the previously proposed relationship between physical activity and CRF, given that PL is an expanded concept of physical activity that more fully describes all components of an active lifestyle (1), In this sense, these concepts may have independent conditioning or, rather than being separate entities, one may influence the other.

Therefore, the relationship between cardiorespiratory fitness and physical literacy is highly relevant, as cardiorespiratory fitness currently plays a crucial role in population health. (12,13), as a result, this suggests that people with low levels of CRF are at greater risk of developing cardio-metabolic risk factors that can be modified by physical literacy (14). Thus, an understanding of the links between these two concepts is essential for implementing health promotion interventions and preventing cardio-metabolic diseases.

Currently, there is a noticeable emphasis in the literature on physical literacy on the development of assessment tools, the aim of which is to enable the accurate analysis and disaggregation of different aspects of physical literacy (15–17). Nevertheless, despite attempts to establish the conceptual relationship between physical literacy, physical activity, and health, it is also imperative to investigate the interrelationship between physical literacy and cardiorespiratory fitness (18). A thorough comprehension of the wide range of empirical evidence on these interrelationships is vital. This knowledge is necessary to endorse evidence-based decision-making in the healthcare sector, as well as adequately steer public policies, schemes for health promotion, and strategies to prevent chronic non-communicable diseases. In addition, a thorough analysis of the empirical evidence can help identify priority areas for research and guide the allocation of resources more efficiently in the quest for improved physical well-being and a healthier society.

Therefore, enhancing physical literacy is a fundamental strategy for supporting consistent, sustainable, and efficient engagement in physical activity programs. In this regard, considering the observation that individuals with an adequate level of physical literacy tend to follow physical activity guidelines more effectively, leading to reduced sedentary behavior and the adoption of an active way of life, an eventual enhancement in cardiorespiratory fitness is expected (8). This approach is relevant in the current context, where health and physical well-being are noteworthy priorities on the public health agenda. (19).

Considering the above, this scoping review aims to explore the relationship between physical literacy and cardiorespiratory fitness as described in the literature by addressing the following research questions:

What is the primary evidence and research documented in the scientific literature that backs up the correlation between physical literacy and cardiorespiratory fitness?

To what extent does physical literacy affect individuals' cardiorespiratory fitness levels, based on previous studies and literature analyses?

What factors could potentially explain the correlation between physical literacy and cardiorespiratory fitness, based on previous research, and what are the possible implications in relation to health promotion and prevention of cardiovascular disease?

Materials and Methods

We use a scoping review approach to gather and integrate information concerning the correlation between physical literacy and cardiorespiratory fitness. The review methodology adhered to Arksey and O'Malley's (20) framework and the subsequent recommendations made by Levac et al. (21). We chose this method for its effectiveness in collecting data to map the extent of the field of study (20). The review was conducted following the guidelines outlined in the PRISMA document for scoping reviews. (PRISMA-ScR; additional file 1) (22).

Search strategy

The search was conducted between August and October 2023, utilizing four databases: Pubmed, Web of Science, Science Direct, and Scopus. Boolean operators were used to

optimize the search results by combining relevant keywords. Table 1 displays the search equations used in each of the databases.

Table 1. Search equations

Database	Equation	# Research articles
Pubmed	("Physical Literacy") AND ("cardiorespiratory fitness" OR "exercise capacity" OR "physical fitness" OR "functional capacity" OR "physical functional performance")	55
ScienceDirect	("Physical Literacy") AND ("cardiorespiratory fitness" OR "exercise capacity" OR "physical fitness" OR "functional capacity" OR "physical functional performance")	82
WOS	("Physical Literacy") AND ("cardiorespiratory fitness" OR "exercise capacity" OR "physical fitness" OR "functional capacity" OR "physical functional performance")	55
Scopus	("Physical Literacy") AND ("cardiorespiratory fitness" OR "exercise capacity" OR "physical fitness" OR "functional capacity" OR "physical functional performance")	67

Selection criteria

In this study, we reviewed all articles that met the following selection criteria: (i) the articles published in academic journals and have undergone peer review in their respective fields; (ii) articles were necessary to discuss the matter of physical literacy and present an in-depth examination of its evaluation procedure; (iii) the inclusion of articles considered direct or indirect assessment of cardiorespiratory fitness and its relation to the concept of physical literacy and, (iv) studies assessing individuals across childhood, adolescence, and adulthood were included without any restrictions on publication year or language.

Studies that looked exclusively at specific populations (i.e. children with musculoskeletal, neurofunctional or metabolic diseases) were not included. The review excluded studies categorized as case reports, conference abstracts, editorial and opinion articles, book chapters, book reviews, and book synopses. However, experimental designs were accepted without any restrictions, meaning studies with no between-group randomisation and/or no control group were also included. Finally, we excluded those articles for which we did not have access to the full text.

Study selection process

The titles and abstracts of identified articles were entered into Rayyan (Intelligent Systematic Review) software to select them based on the inclusion and exclusion criteria In accordance with the scoping review methodology, two reviewers conducted an article evaluation process in two phases, whereby they first examined the titles and abstracts of the articles, and in the second phase, they completed a full-text review (23, 24). In the event of any disagreements arising during the initial review of an article, a third reviewer was called upon to resolve it. Upon completion of the review process, only one disagreement was found, related to the characteristics of the sample. This point of discrepancy was resolved by the third author, who included it in the revision of the current manuscript.

Findings synopsis

Excel spreadsheets were used for structuring and sorting the data. Descriptive statistical techniques were then applied to synthesize information on the number of publications per year, country of origin, and study desig (25). In addition, tables were constructed to systematize the extracted data related to the demographic information of the participants in the studies as well as physical literacy and potential correlation with cardiorespiratory fitness.

Results

The search across the four databases resulted in 259 scientific articles. From these, after removing duplicates and assessing by title and abstract, only 15 articles were retained. After examination of the full-text articles, 10 papers were found to meet the inclusion criteria and scope of this review (Figure 1).

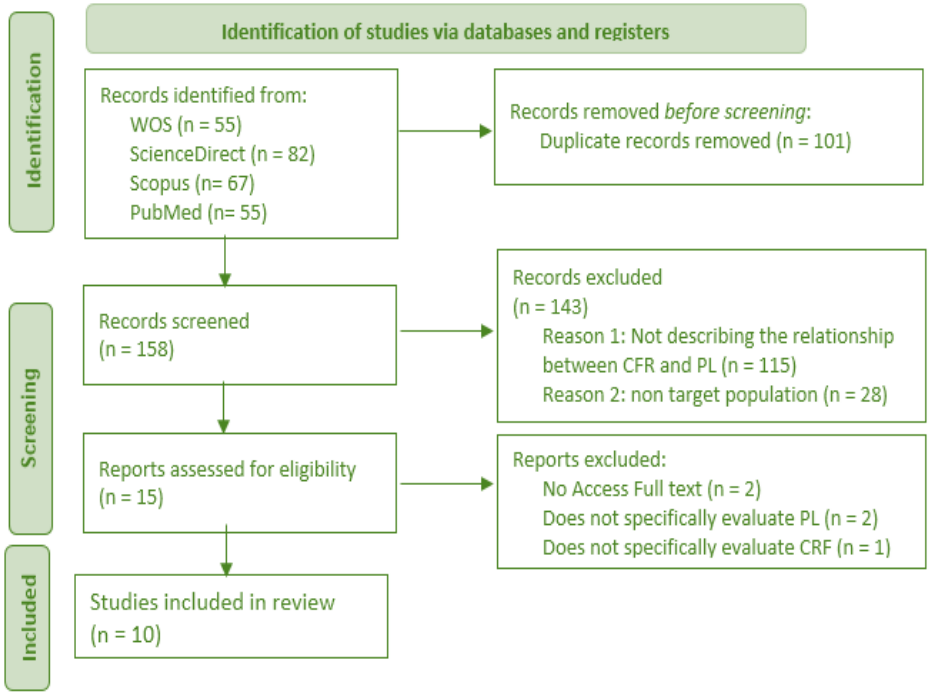

Figure 1. PRISMA flow diagram showing the process of study identification and selection (26).

All primary research studies included in the analysis employed quantitative approaches. The research designs identified included cross-sectional studies (27–33), quasi-experimental studies (34, 35), and prospective studies (36). Of these, six studies focused on exploring the relationship between (CRF) and (PL) in schoolchildren up to 12 years of age (29, 30, 33, 34, 36, 37), while the remaining studies focused on schoolchildren older than 12 years old. (31, 38) and/or university students. (32, 35). No studies of adults aged 21 years or older were found in the literature reviewed. Refer to Table 2 for a summary of each of the reviewed articles.

The Canadian Assessment of Physical Literacy, second edition questionnaire was employed to evaluate physical literacy in five out of the ten articles. (CAPL-2) (28, 30, 34,

36, 38); two studies reported on the use of the Perceived Physical Literacy Instrument (PPLI) (32, 33), while two other studies mentioned the use of the tools PLAY (29, 35). In one case, the measurement tool used for PL was not specified. (34).

In the case of cardiorespiratory fitness assessment, all of the studies analyzed assessed CRF indirectly, 90% of the studies analyzed used the 20 or 15-m shuttle run test. (28, 30–36, 38). Only a single study has reported employing the modified Bruce protocol executed on a treadmill. Additionally, the same author suggests measuring the percentage of heart rate recovery 1 minute following exercise as an indicator of CRF. (29).

All cross-sectional studies (27–33) explored the association between different health indicators and physical literacy. These indicators include IBM, handgrip strength, body weight, peak growth velocity, and cardiorespiratory fitness. The studies found that each of these indicators was statistically associated with all domains of physical literacy, particularly the physical domain, and the total score of all measurement tools.

All cross-sectional studies indicate a positive association between cardiorespiratory fitness (CRF) and physical literacy (PL) in both genders. Notably, Nezondet C. et al. (33) observed that for each additional point in the total PPLI score, there was a corresponding increase of 0.33 ml/kg/min in maximal oxygen consumption. When examining the relationship between each PL component, Zhang C. et al. (32) found that the physical component demonstrated a significant correlation with CRF, with values of r=0.27 for males and r=0.15 for females. However, the components of motivation and interaction with the environment exhibited a correlation with males only, with values of r=0.13 and r=0.14, respectively. The above findings show partial similarities with the research of Lang J. et al. (28), who found a significant relationship between (CRF) and physical literacy (PL) components. Across all age and gender groups, this relationship remained stable and consistent. Effect sizes, as measured by Cohen's d index, ranged from small to large, with a minimum number of PL components considered insignificant. Overall, more pronounced effect sizes were observed for boys than for girls, and these effect sizes tended to increase with age. In the specific case of physically active adolescents or schoolchildren, Sunda M et al. (38) explain that in this population they obtained higher CAPL-2-KU scores, higher scores on three of the five PLAYself subscales and, as a whole, higher PLAYself total scores. However, despite these differences, in the overall sample, the results of all the PLAY tests correlated consistently and positively with the long jump test, the abdominal test, and the 20-m running protocol. In the case of quasi-experimental studies, positive effects on CRF following a PL-based intervention are highlighted. In this regard, Zhang D. et al. (34) found a significant interaction between the groups and the different assessment times for 20 m shuttle run test (β = -3,89, IC del 95 % [-5,08; -2,71], $p < 0,001$). However, the post-test performance of the children in the intervention group was significantly higher than that of the control group ($p < 0.001$), results that are consistent with those reported by Kwan. M et al. (35) and Nezondet C. et al. (36).

Table 2. Detailed summary of original research articles (n = 10)

Author	Article title	Country	Type of study	Objective	Population	Sample	PL measurement tool	CRF evaluation tool/test	Main results	Conclusions
Lang J. et al 2018	Cardiorespiratory fitness is associated with physical literacy in a large sample of Canadian children aged 8 to 12 years	Canada	Crossectional study	Evaluate the associations between 20 m shuttle run test performance (i.e., CRF) and each component of PL assessed using the CAPL in a large sample of Canadian school-aged children (8–12 years).	Children between 8 and 12 years old	9399 children aged 8–12 years, from 11 Canadian sites and seven Canadian provinces	Canadian Assessment of Physical Literacy (CAPL-2)	CRF was assessed using the 15 m or 20 m SRT protocols. The 15 m protocol was used only if there was not enough space to carry out the full 20 m protocol.	The CRF was categorized into tertiles (low, moderate and high), finding significance with PL components that were consistent and in the expected direction across all age and gender groups. The effect sizes (Cohen's d) between low and high CRF groups ranged from small to large, with very few components of PL considered trivial Generally, larger effect sizes were observed for boys than girls, and the effect sizes generally increased with age. The Physical competence domain score consistently displayed the largest effect size (Cohen's d range: 1.11–1.94) across age and gender groups, followed by the total CAPL score (Cohen's d range: 0.92–1.60)	This study identified strong favorable associations between CRF and all components of PL in a large sample of school-aged Canadian children. This supports the importance of CRF as a possible predictor of PL outcomes.

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Nezondet C. Et al 2023a	Perceived Physical Literacy Is Associated with Cardiorespiratory Fitness, Body Composition and Physical Activity Levels in Secondary School Students	France	Crossectional study	Investigate the relationships between PL, body composition, cardiorespiratory fitness and physical activity levels in French secondary school students.	Children of 6th grade	A total of 85 adolescents, including 32 girls and 53 boys with an average age of 12.1 (+/- 0.4) years, participated in our study.	French version of the Perceived Physical Literacy Instrument (F-PPLI).	20 m adapted walk/shuttle run test	A significant positive association was found between the PL score and CRF with aerobic capacity as an indicator (r = 0.40; B = 0.33 (0.13; 0.53); p <0.05). This study also found positive associations between the PL score and the moderate to vigorous physical activities per week (r = 0.38; B = 13.97 (5.88; 22.06); p < 0.01). Each additional point on the PPL score, aerobic capacity increases by 0.33 mL/kg/min.	This study shows that in French secondary school students, the level of PPL is positively associated with CRF, MVPA, and the % of skeletal muscle mass and negatively associated with the % fat mass. This study suggest that a good level of PL is associated with good CRF, high levels of PA, and positive health markers.
Zhang C. Et al 2022	Exploring the Level of Physical Fitness on Physical Activity and Physical Literacy Among	Chongqing, China.	Crossectional study	This study aims to examine the impact of the physical fitness level (fit/unfit) on PA and PL, as well as the	Students from Schools, Colleges, and universities with a mean age of 19.2	a stratified sampling method to recruit participants from four schools located in the Gaoxin district of Chongqing, China. 798 university	The Perceived Physical Literacy Instrument (simplified Chinese version)	Aerobic fitness was measured by a long-distance race of 800 m for women and 1,000mfor men. Participants were tested in pairs, starting from a standing position. The score was recorded in	Significant differences were found between sexes in CRF, strength and sedentary behavior; but not between the different attributes of PL. The attribute of confidence and	Among the attributes of PL, confidence and physical competence showed relatively greater

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	Chinese University Students: A Cross-Sectional Study			relationships among PF, PA, and PL, in Chinese university students.	years located in the Gaoxin district of Chongqing, China	students were recruited (390 men, 48.9%), with a mean age of 19.2 years		minutes and seconds and was validated by two research assistants. The final grade was calculated according to the national physical fitness measurement standards manual system, with 100 points as the highest grade.	physical competence was significantly correlated with muscular strength and aerobic fitness in both men (r = 0.11 and r = 0.27, respectively) and women (r = 0.18 and r = 0.15, respectively), while the attributes of motivation and interaction with the environment were significantly associated with aerobic fitness (r = 0.13 and r = 0.14, respectively) and vital capacity (r = 0.11 and r = 0.13, respectively) in men. The total level of PL was significantly correlated with vital capacity and aerobic fitness in both men (r = 0.11 and r = 0.22, respectively) and women (r = 0.11 and r = 0.11, respectively).	positive associations with the aspects of PF in Chinese university students, while no significant relationship was observed between PF and PA.
Gilic B. et al 2022	Adolescents with Higher Cognitive and	Osijek-Baranja County, Croatia	Crossectional study	the aims of the study were (i) to evaluate the reliability and	Students of two high schools in Osijek-Baranja	This research included 544 adolescents (403 females, 141 males) aged 14–18	The CAPL-2 knowledge and understanding questionnaire (CAPL-2-KU) and PLAYself	A multilevel endurance fitness test was used (beep test was conducted using an alternative 15 m	Boys were taller and had greater body mass and body mass index than girls. Boys achieved better	The finding that the PF level is not strongly related to

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	Affective Domains of Physical Literacy Possess Better Physical Fitness: The Importance of Developing the Concept of Physical Literacy in High Schools			applicability of the Croatian version of two common PL measurement and (ii) to establish the validity of the applied questionnaires while establishing (ii-a) gender differences in applied tools and (ii-b) the associations between the cognitive and affective domains of PL and objectively measured health-related PF in high school adolescents.	County, Croatia	years. All students were in good health and did not have any injury or illness during the investigation, which was determined by regular medical examination at the beginning of the school year	questionnaire were used to assess the cognitive and affective domains of PL.	protocol). This test is usually performed on 20 m lines, but its utility has been proven even at 15 m distances in children and adolescents	results in all fitness tests except for flexibility, where girls reached better scores. Boys and girls achieved similar scores in CAPL-2-KU (scores of 8.63 and 8.52, $p > 0.6$) and PLAYself total score (scores of 69.26 and 67.66, $p > 0.05$). Specifically, CAPL-2-KU was significantly associated only with the sit-and-reach test (4% of the common variance) in boys. Meanwhile, fitness tests (standing long jump, sit-ups, and beep test) were significantly associated with PLAYself total score (3% to 17% of the common variance), subsection of environment (4% to 17% of the common variance), self-description (5% to 25% of the common variance), and ranking of physical literacy (8% to 8% of	the cognitive domain of PL, assessed with the PL questionnaire regarding knowledge and understanding of PA, is worrying. This points to a problem in Croatia's school and sports system, which is /almost exclusively based on the development of PF and motor skills. On the other hand, the cognitive domain of PL seems to be inadequately developed both through the PE school curriculum and sports system.

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									the common variance).	
McDonald et al. 2018	A cross-sectional study exploring the relationship between age, gender, and physical measures with adequacy in and predilection for physical activity	Canada	Crossectional study	the purpose of this study was to investigate how participants' age and gender, along with the Physical Competence components of PL, relate to their adequacy in and predilection for physical activity.	Children between 8 and 12 years old	10,034 children aged 8–12 years, from 11 Canadian sites and seven Canadian provinces.	Canadian Assessment of Physical Literacy (CAPL-2)	Progressive Aerobic Cardiovascular Endurance Run (PACER) shuttle run score (number of 20-m laps)	The variable most strongly asssociated with both adequacy and predilection for PA was the PACER shuttle. The second and third variables most strongly associated with the outcome variables were the CAMSA score (r2 = 0.019 for adequacy; r2 = 0.016 for predilection) and age of the participant (r2 = 0.006 for adequacy; r2 = 0.01 for predilection). run, at 10.9% of the variance in adequacy and 9.9% of the variance in predilection	The results from this study revealed that Physical Competence elements of PL (especially cardiorespiratory fitness and fundamental /complex movement skills) were related to the psychological constructs of adequacy in and predilection for physical activity.
Sunda M et al. 2022	Out-of-School Sports Participation Is Positively Associated with Physical Literacy, but What about	Dakovo, Croatia,	Crossectional study	this study aimed to evaluate the possible gender-specific associations between (i) PF, (ii) sports participation, and (iii) involvement/	Students (14-18 years) from Croatia	298 adolescents aged 14 - 18 years from Croatia (191 females, 16.19 +/- 1.25 years, 107 males, 16.02 +/- 1.23 years). all participants were attending high school and were of good health (they did not have any	To estimate physical literacy, the CAPL-2-KU and PLAYself questionnaires were administered via the online platform SurveyMonkey (SurveyMonkey Inc., San Mateo, CA, USA).	The multilevel beep test is used to assess students' aerobic endurance. It.	Among the total sample not divided by gender, participants involved in out-of-school sports were taller and heavier and achieved better results for all PF variables except the sit-and-reach test of flexibility than their	This study recorded that adolescent involved in sports had better PL and better fitness status compared with adolescents

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	Physical Education? A Cross-Sectional Gender-Stratified Analysis during the COVID-19 Pandemic among High-School Adolescents			achievement in PE and PL among Croatian high schoolers		medical condition that would prevent them from participating in fitness tests).			nonathletic peers. further, athletic adolescents had higher CAPL-2-KU scores, higher scores on three of the five PLAYself subscales, and higher total PLAYself scores. Finally, for the total sample of participants, the PLAYself total score and the PLAY environment and PLAY self-description subscale scores were consistently positively correlated with the broad jump, sit-up, and beep tests with 10–25% of the shared variance	who were not involved in sports. Therefore, it seems that sports clubs offer a good base for developing habits of lifelong PA participation
Zhang D et al. 2023	Effects of integrating physical literacy into active school recess intervention on physical fitness and academic performanc	China	A quasi-experimental study	The aim of this study was to examine the effects of school-based intervention integrating physical literacy (PL) into active school recesses (ASR) on	Participants from primary schools (grade 1 and grade 2) of two schools in Shanghai	The sample size was determined by priori analysis in G*Power 3.1 software. A total of 357 children were recruited for this study. Among them, intervention group comprised 155 children (mean age: 7.9 ± 0.7ys, boys: 51.0%), while control group	Intervention PL-ASR (active school recesses)	Cardiorespiratory fitness was assessed using the 20-m shuttle run test	A significant group × time interaction was observed for the 20-m shuttle run (β = -3.89, 95% CI [-5.08; -2.71], p < 0.001). The equation Y = -2.51 + 0.25 × Gender - 3.05 × Week + 4.52 × Group + 2.00 × Age - 3.89 × [Week × group] was used to analyze the data. Both groups showed	This study indicated that intervention integrating PL into ASR can promote health-related physical fitness especially for aerobic fitness and

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	e in Chinese School children: A Cluster Randomized Controlled Trial			physical fitness (i.e., body composition, 20-m shuttle run, 50-m run, rope skipping, sit and reach, handgrip) and academic achievement (i.e., academic result of Chinese and Mathematics) in Chinese		included 202 children (mean age: 7.8 ± 0.7ys, boys: 50.0%)			a significant positive improvement ($p < 0.001$), with IG demonstrating a greater increase compared to CG. Furthermore, the post-test performance of children in IG was significantly higher than that of those in CG ($p < 0.001$).	strength. Also, such intervention is also beneficial to enhance academic achievement. These findings suggest that blended PL framework based on school setting could be a potential approach to promote health and development forchildren. It is recommended that future studies evaluate the longer-term effects PL intervention.
Caldwell H. Et al 2020	Physical Literacy, Physical Activity, and Health Indicators in School-	Canada	Cross-sectional study	The purpose of this study is to investigate the associations between	Participants in this study were part of the school-age kids health from early	Two hundred and forty-nine participants (121 girls, 128 boys) took part in the lab-based assessments	A composite physical literacy score was calculated using the standardized scores from PLAYfun, PLAYparent, and PLAYself.	Aerobic fitness was assessed using a modified Bruce Protocol, a progressive treadmill test that increases in speed and grade every 3 min.	There were no differences between boys and girls in age, height, weight, BMI or BMI% (p 294–0.904). Girls had smaller peak growth	The present study determined that physical literacy was associated with health,

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	Age Children			physical literacy and health, and if this relationship is mediated by moderate-to-vigorous physical activity (MVPA) and (CRF).	investment in physical activity (SKIP) study	of year 3 of the SKIP study, and 222 completed consent and assent forms to participate in the physical literacy assessments (113 girls, 109 boys, 10.7 +/- 1.0 years).	Standardized scores were summed and higher values suggested greater physical literacy.	The second indicator of aerobic fitness was 60 s HR recovery (HRR), calculated as the deference between the peak HR (single beat highest value) and HR 60s into recovery.	rate values, suggesting that they were more mature than boys ($p<0.001$), and displayed a higher %BF than the boys ($p<0.001$). The boys exhibited longer treadmill times ($p= 0.005$) and faster 60 s HRR ($p <0.001$). The physical literacy composite score and YPHV were associated with body fat ($R2 = 0.228$, $F (3,205) = 20.19$, $p < 0.001$) and MVPA ($R2 = 0.235$, $F (3,192) = 16.61$, $p < 0.001$). The physical literacy composite score, sex, and YPHV were associated with systolic blood pressure ($R2 = 0.109$, $F (3,204) = 8.31$, $p < 0.001$).	represented as body composition, fitness, blood pressure, and health related quality of life and that the association between PL and aerobic fitness was mediated by MVPA.
Kwan. M et al 2020	Stopping the Drop: Examining the Impact of a Pilot Physical Literacy-Based Interventio	Canada	A quasi-experimental study	The purpose of the current study was to evaluate the impact of a pilot PL-based intervention	university students	Included a final sample of 65 first-year university students (age = 17.85 +/- 0.51)	Movement competence was assessed using the PLAYfun tool, Motivation was assessed by the Relative Autonomy Index calculated using the	The Leger 20 m Shuttle Run test. Cardiorespiratory fitness (CRF) was also predicted using the equation: y=31.025 + 3.238 (maximal speed) - 3.248 (age, years) + 0.1536 (speed*age)	The results from repeated measures ANOVAs assessing changes in aerobic fitness scores revealed no significant main effects for time ($p > 0.05$). However,	The current study found a PL-based intervention program to be helpful in students to attenuate the decline

Author	Article title	Country	Type of study	Objective	Population	Sample	PL measurement tool	CRF evaluation tool/test	Main results	Conclusions
	n Program on Physical Activity Behaviours and Fitness during the Transition into University			on PA and fitness for students transitioning into university			Behavior Regulation in Exercise Questionnaire-3 (BREQ-3)		noteworthy time by condition interactions were observed for laps completed ($F(1, 61) = 10.01$, $p = 0.002$), final stage achieved ($F(1, 61) = 8.36$, $p = 0.005$), and cardiorespiratory fitness global (CRF) ($F(1,61) = 8.35$, $p = 0.005$).	typically observed for PA behaviors and maintain aerobic fitness.
Nezondet C. Et al 2023b	The Effectiveness of a Physical Literacy-Based Intervention for Increasing Physical Activity Levels and Improving Health Indicators in Overweight and Obese Adolescents (CAPACITES 64)	France	A prospective interventional study with a single arm and not randomized.	This study presents the results of an intervention developing PL in overweight and obese adolescents. The main objectives were as follows: Develop PL among adolescents and Increase MVPA and improve health indicators (body composition and CRF) among	Sixth grade students from a French school	Participants for this intervention were recruited from the baseline sample (4 volunteer sixth-grade classes at Marracq Middle School (n = 85)) found in the study by Nezondet et al.	Adolescents' PL was measured by the Canadian Assessment of PL Second Edition (CAPL-2).	The CRF was assessed by the CRF on the adapted 20 m shuttle run/walk test	Between T0 and T1 the total PL score increased by 8.3 (+/- 9.3) points (51.5 to 59.8) equivalent to 16% ($p < 0.01$). The development of PL was expected to improve health indicators and increase MVPA. Regarding health indicators, the 9 months of intervention significantly increased Vmax by 0.5 km/h (+/-0.7) equivalent to 5.7% ($p = 0.03$), and VO2peak by 1.5 mL/min/kg (+/- 1.7) equivalent to 4.8% ($p < 0.01$) in the adolescents	This study proposes that implementing interventions to enhance motor literacy (PL) in overweight and obese adolescents represents a promising strategy. Notably, the initial findings at 9 months indicate an improvement in motor literacy scores, an increase in

Author	Article title	Country	Type of study	Objective	Population	Sample	PL measurement tool	CRF evaluation tool/test	Main results	Conclusions
				overweight and obese adolescents					group. The relationship between PL score and VO2peak is also positive at T0 and T1 ($p<0.01$). This means that the PL score is strongly associated with VO2peak and when the score increases, VO2peak also increases. In contrast to baseline results (T0) ($r = 0.31$), the MVPA variable and VO2peak are associated at 9 months (T1) ($r = 0.81$; $p < 0.01$).	cardiorespiratory fitness (CRF) and skeletal muscle mass percentage (%SMM), along with a reduction in body fat percentage (%BF). Furthermore, fostering motor literacy appears crucial in preventing the decline in moderate-to-vigorous physical activity (MVPA) observed during adolescence in this specific population.

Discusion

Our scoping review sought to elucidate the relationship between physical literacy (PL) and cardiorespiratory fitness (CRF) by addressing three key research questions. Firstly, we examined the primary evidence and research documented in the scientific literature supporting the correlation between PL and CRF. Our analysis revealed a consensus among studies regarding a direct relationship between physical literacy, particularly its physical domain, and CRF. This alignment with existing literature underscores the validity and relevance of our findings.

All of the studies reviewed included the definition of Physical Literacy set out by Dr Margaret Whitehead (1, 39) indicating that the field as a whole is moving towards a consensus definition of physical literacy. This is in line with what is proposed by the review of Cornish et al. (18), as well as a focus on the development of knowledge, skills, and attitudes necessary for people in general to lead active and healthy lifestyles and to enable the development of lifelong physical activity (40).

Secondly, we explored the extent to which physical literacy influences individuals' cardiorespiratory fitness levels. While evidence from interventions and descriptive studies suggests a positive correlation between PL and CRF, establishing causality remains challenging. Evidence from studies suggests that physical literacy-based interventions result in significant enhancements in physical fitness, particularly cardiorespiratory fitness, in children and youth (34–36). Likewise, descriptive studies have shown a positive correlation from high to moderate between physical literacy and CRF (28–33, 38). However, these correlations do not establish a causal relationship between PL and CRF, therefore, it cannot be established which variable produces and explains the observed behavior between both variables (41), Moreover, the link between physical literacy and this ability is not yet well established and demonstrated in prospective studies. It is uncertain whether physical literacy improves cardiorespiratory performance or whether individuals with superior performance or more advanced physical fitness possess higher levels of physical literacy. Thus, although many studies have explored the assessment and characterization of physical literacy and physical fitness in schoolchildren and adolescents, the existing evidence regarding the connection between these two variables limits the possibility of arriving at definitive conclusions. This suggests that, given previous evidence on physical activity levels and their association with cardio-respiratory fitness, an improvement in PL may in turn lead to an increase in CFR (28, 33, 42).

Lastly, we investigated factors that could potentially explain the correlation between PL and CRF and their implications for health promotion and cardiovascular disease prevention. While our review acknowledges the interconnectedness of physical literacy, physical activity, and cardiorespiratory health, we recognize the need for a more in-depth exploration of this relationship. Specifically, we acknowledge the potential role of physical literacy interventions in promoting cardiovascular health and preventing disease. However, further research is needed to elucidate the

mechanisms through which physical literacy may impact cardiovascular health outcomes.

In conclusion, the data collected in this review show a clear association between LP and CFR in both children and adolescents, although there is no definitive evidence of a causal relationship. This raises important questions about the practical implications of improving these variables in this age group. For example, what should be the best starting point for an intervention? Promotion of cardiorespiratory fitness, physical activity, physical fitness, or strengthening physical literacy? At this point, although physical literacy is a foundational concept that underpins participation in physical activity, there is a possibility that physical activity or cardiorespiratory fitness may enhance physical literacy, and vice versa. This is reinforced by the findings of Sunda M. et al. (38) which demonstrate that adolescent athletes who perform better in (CFR) also achieve higher scores in (PL). To provide context, Figure 2 illustrates the reciprocal relationship between physical literacy and physical activity and its influence on cardiorespiratory health.

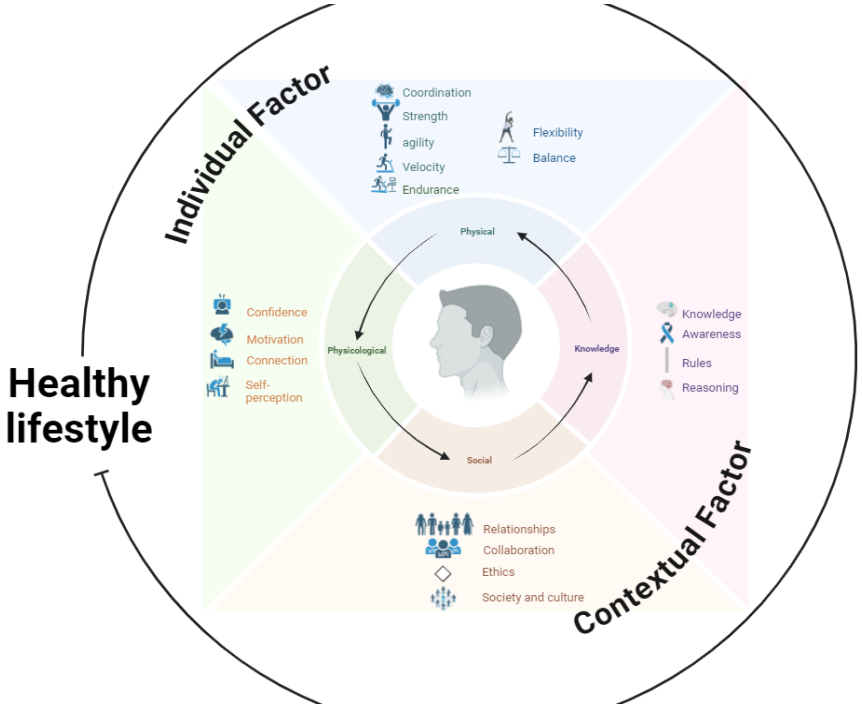

Figure 2. Reciprocal relationship between PL and health

The proposed model identifies PL as the primary health and disease determinant. Physical activity exposure acts as a mediator that triggers acute and chronic physiological adaptations that optimise health status. Furthermore, the model takes into account the potential impacts of personal and situational variables that may affect or interact with this connection.

To simplify, PL was described as an interrelated and intertwined concept of physical, social, psychological and cognitive factors, in line with their accepted definitions (1, 43, 44). It is noteworthy the cyclic

relationships between these components highlight the interdependence of physical motor competence and their emotional and motivational aspects.

In our perspective, this description underlines the importance of looking at the dynamic interrelationships between these concepts, as opposed to a 'summative' assessment of these components. These interconnections reinforce the notion of CP as a holistic concept. By this, we mean that PL is presented as a cycle in which the relationships between motor competences, social, affective, and motivational processes and knowledge are seen as interdependent. For example, success in learning a new skill through physical activity can create a sense of motor competence. This, in turn, increases confidence to participate with others and results in positive emotional states such as enjoyment and a sense of fun. Likewise, having a previously acquired skill increases confidence to participate with others and produces positive emotional states. This constant interplay between skill acquisition, motor competence, confidence, and emotional satisfaction creates a virtuous cycle that motivates and engages the individual in physical activity. This continuous cycle of positive feedback plays a key role in fostering sustained participation and well-being in physical activity.

Study Limitations and Strengths: Although all members of the research group carefully reviewed all included articles during full-text selection, there is a possibility that some bias may have been introduced during the review of the manuscripts. Because we were interested in exploring physical literacy and the relationship with CRF, our search term included the keyword “physical literacy.” A more comprehensive review may consider a search using keywords for each of the individual domains of physical literacy (e.g., motivation, affect) to more comprehensively determine the relationships between the domains of physical literacy and CRF using a more robust analysis.

Conclusions

This review seeks to improve understanding of the concept of physical literacy and its connection to cardiorespiratory fitness (CRF). Although efforts are being made to understand the measurement of each specific domain of physical literacy, its application in the field of health and sport is not yet fully established or understood in the academic literature. The relationship between physical literacy, physical activity, and cardiorespiratory fitness requires further exploration, considering the theoretical foundations of physical literacy. This work is essential to clarify the role of physical literacy as a driver to encourage physical activity, reduce the burden of disease, and improve health and well-being.

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Conflicts of interest: The authors declare that they have no conflict of interest.

Consent for publication: Not applicable.

Ethical Approval and consent to participate: Because this study is a scoping review, its primary objective is the synthesis and critical analysis of the existing literature. As the research does not involve the collection of primary data or the direct involvement of humans in the study, formal approval by an ethics committee or obtaining informed consent from participants is considered unnecessary. It should be noted that this approach aligns with the principles outlined in the Declaration of Helsinki, ensuring ethical standards are upheld even in literature-based reviews.

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