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Gender comparison in physical literacy: a systematic review and meta-analysis of children and adolescents

Comparación de género en la alfabetización física: una revisión sistemática y meta-análisis de niños y adolescentes

*Ahmad Chaeroni, **Desy Syswianti, ***Muchamad Arif Al Ardha, ****Lutfi Nur, *****Mottakin Ahmed, ******Kamal Talib, *******Bekir Erhan Orhan, ********Mert Kurnaz, ******Mohd Nizam Lani

*Universitas Negeri Padang (Indonesia), **STIKes Karsa Husada Garut (Indonesia), ***Universitas Negeri Surabaya (Indonesia), ****Universitas Pendidian Indonesia (Indonesia), *****Government College Silwani (India), ******Universiti Malaysia Terengganu (Malaysia), *******Istanbul Aydın University (Türkiye), ********Haliç University (Türkiye)

Abstract. This study conducts a systematic literature review and meta-analysis on physical literacy, with a focus on gender comparisons among school-aged children and adolescents. Physical literacy (PL) is a multidimensional concept involving social and environmental interaction, knowledge and understanding, motivation and confidence, as well as physical competence. The aim of this study is to evaluate the impact of interventions on these domains and to examine the existing gender gap. The methods employed include a Systematic Literature Review (SLR) and meta-analysis, with data sourced from the Scopus and PubMed databases. The analysis was performed using fixed and random effects models, with publication bias evaluated through Funnel plot, Rank Correlation Test, and Egger's Test. The results indicate that PL interventions have significant effects on several domains with gender-based differences. The social and environmental interaction domain showed no overall significant effect, whereas the knowledge and understanding, and motivation and confidence domains exhibited small but significant effects, with females tending to demonstrate better outcomes. The physical competence domain showed a moderate and significant influence, with males showing greater improvement. The overall physical literacy domain exhibited a significant positive effect, emphasizing the importance of a holistic approach in PL interventions. These findings provide evidence-based recommendations for more inclusive physical education practices and school policies, and help address the gender gap in the development of physical literacy.
Keywords: Physical literacy, gender, children and adolescents, domains, potential development

Resumen. Este estudio realiza una revisión sistemática de la literatura y un meta-análisis sobre la alfabetización física, con un enfoque en las comparaciones de género entre niños y adolescentes en edad escolar. La alfabetización física (AF) es un concepto multidimensional que implica interacción social y ambiental, conocimiento y comprensión, motivación y confianza, así como competencia física. El objetivo de este estudio es evaluar el impacto de las intervenciones en estos dominios y examinar la brecha de género existente. Los métodos empleados incluyen una Revisión Sistemática de la Literatura (RSL) y un meta-análisis, con datos obtenidos de las bases de datos Scopus y PubMed. El análisis se realizó utilizando modelos de efectos fijos y aleatorios, con la evaluación del sesgo de publicación mediante el gráfico de embudo, la prueba de correlación de rangos y la prueba de Egger. Los resultados indican que las intervenciones en AF tienen efectos significativos en varios dominios con diferencias basadas en el género. El dominio de la interacción social y ambiental no mostró un efecto significativo general, mientras que los dominios de conocimiento y comprensión, y de motivación y confianza, exhibieron efectos pequeños pero significativos, con una tendencia de mejores resultados en las mujeres. El dominio de la competencia física mostró una influencia moderada y significativa, con una mayor mejora en los varones. El dominio general de la alfabetización física mostró un efecto positivo significativo, enfatizando la importancia de un enfoque holístico en las intervenciones de AF. Estos hallazgos proporcionan recomendaciones basadas en evidencia para prácticas de educación física más inclusivas y políticas escolares, y ayudan a abordar la brecha de género en el desarrollo de la alfabetización física
Palabras clave: Alfabetización física, Género, Niños y adolescentes, Dominios, Desarrollo potencial

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Ahmad Chaeroni
ahmad.chaeroni@fik.unp.ac.id

Introduction

In the field of health and physical education (HPE), sports, recreation, and public health, the concept of physical literacy has become increasingly popular among educators, professionals, and policymakers (Lundvall , 2015; Pot et al., 2018). Physical literacy (PL) has also emerged as a means to promote physical activity among children (Belanger et al., 2018; Cairney et al., 2019; Gusril et al., 2024; Maidawilis et al., 2022). Physical literacy (PL) focuses on the development of human potential symbolized through efficient and meaningful interactions with the world (Durden-Myers et al., 2018). In educational settings, adopting PL as a fundamental guiding objective for PE worldwide (Roetert & MacDonald, 2015; M. Whitehead, 2019).

Physical literacy (PL) can be addressed both within and outside of educational settings. Castelli and Centeio (Castelli et al., 2014) highlight that, within educational settings, the curriculum can contribute to PL in several ways: distinguishing between structured, unstructured or informal physical activities (recess), or through activity instruction. physics rich in content. (integrating academic concepts with movement). Consequently, numerous studies have begun to explore PL both within physical education (PE) classes (Coyne et al., 2019; Kriellaars et al., 2019; Sepriadi et al., 2024) and during out-of-school periods (Bremer et al., 2020; Mandigo et al., 2019).

The theoretical construct of physical literacy (PL) is

currently discussed with various interpretations in the scholarly literature (Edwards et al., 2017). Physical literacy (PL) can be addressed both within and outside educational environments. Castelli and Centeio (Castelli et al., 2014) highlight that, within educational settings, the curriculum can contribute to PL in several ways: distinguishing between structured, unstructured, or informal physical activities (recess), or through content-rich physical activity instruction (integrating academic concepts with movement). Consequently, numerous studies have begun to explore PL both within physical education (PE) classes (Coyne et al., 2019; Kriellaars et al., 2019) and during out-of-school periods (Bremer et al., 2020; Mandigo et al., 2019).

Physical literacy has demonstrated a positive correlation with lifelong participation in movement activities, as well as increased self-esteem, reduced injuries, and social foundations (Cairney et al., 2019). Researchers acknowledge the concept of physical literacy across the lifespan (M. Whitehead, 2013), yet studies predominantly focus on children and adolescents (Edwards et al., 2017; Roetert & MacDonald, 2015). Considerable discussion has arisen regarding the extent to which these programs succeed in creating positive physiological changes, mental health improvements, and enhanced academic achievement, thereby promoting long-term participation in physical activities (Daly-Smith et al., 2019; Fairhurst & Hotham, 2017; Thorburn, 2020; Okilanda et al., 2024). Physical literacy can be described as a "multifaceted concept" encompassing interconnected affective, physical, and cognitive domains (Cornish et al., 2020; Edwards et al., 2017; Shearer et al., 2021). By including these three domains, physical literacy (PL) is capable of capturing a range of processes that contribute to lifelong learning and engagement in physical activities (Cairney et al., 2019; J. Whitehead et al., 2013; Al Ardha et al., 2024).

Taking into account the assumptions about the benefits of physical literacy (PL) that have been proposed, this study aims to conduct a systematic literature review (SLR) and meta-analysis on physical literacy with a focus on gender comparisons between children and adolescents of school age. Although meta-analysis studies have been conducted on physical literacy (Carl et al., 2022), an identified weakness is the lack of specific focus on comparing outcomes between men and women. This study evaluates this intervention according to the different yet interrelated domains of PL, namely Social and Environmental Interaction (SEI), Knowledge and Understanding (K&U), Motivation and Confidence (M&C), and Physical Competence (PC). In addition to these domains, this study includes Total Physical Literacy (TPL) as an addition. The results of this study are expected to provide evidence-based recommendations for more inclusive physical education practices and school policies, helping to address gender disparities in physical literacy development. Consequently, this research will contribute to promoting gender equality and improving the quality of physical education in schools, as well as providing information for more effective long-term health strategies.

Materials and Methods

This study employs the Systematic Literature Review (SLR) method, an approach designed to discover, assess, and interpret all available and relevant information in literature or references to comprehensively address research questions (Snyder, 2019; Xiao & Watson, 2019). SLR aids in providing a summary of current knowledge or topics related to the research question (Kurniati et al., 2022). It serves as a valuable source of information where authors need to summarize and evaluate credible scientific literature using organized methods based on predefined objectives, thus enabling use by other researchers (Gopalakrishnan & Ganeshkumar, 2013).

The data sources for this study were obtained through searches in the Scopus database, which encompasses high-quality scientific literature across more than 250 disciplines, including social sciences and humanities (Cretu & Morandau, 2020). Additionally, we utilized sources from PubMed. The literature review method chosen for this study utilizes the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology (Page et al., 2021). PRISMA, introduced in 2009 (Moher et al., 2009), is considered one of the best methods to conduct systematic reviews and meta-analyses correctly, aiding authors in reviewing the structure such as roadmap. PRISMA is also the most frequently used method in articles such as literature reviews (Hutton et al., 2016; Moher et al., 2016; Shamseer et al., 2015; Stewart et al., 2015).

Table 1.
The inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
Years 2019-2024	Before 2019
Type of empirical research articles	Types of books, book chapters, theses, short reports, and conference presentations.
The term 'physical literacy' only appears in the titles of articles indexed in Q1-Q4 (Scopus database) and in the titles and abstracts in the PubMed database	Not present in the article titles and outside the Q1-Q4 index (Scopus database) and outside the titles and abstracts of the PubMed database
Age of the students, or equivalent (school or college)	Gender Difference Data
Data according to gender	Undifferentiated

Search Strategy and Data Extraction

The search strategy employed data from the PubMed database, while for the Scopus database, the Watase Uake search tool was used, specifically designed for Scopus data, with the query "(student* OR child*) AND physical literacy" as the search strategy. Article selection was limited to

new publications within the last five years (Paul et al., 2021), specifically from 2019 to the current year, 2024. For the Scopus database, only articles indexed in quartiles 1 (Q1) to 4 (Q4) were considered. Eligibility criteria were essential for selecting appropriate articles (Ahmadi et al., 2018). Articles were filtered based on inclusion and exclusion criteria as outlined in Table 1.

The data extraction process was conducted meticulously to ensure the accuracy and consistency of information obtained from each included study. Extracted data included study design, participants' demographic characteristics, analyzed domains of physical literacy, effect sizes and standard deviations by gender for each domain, main findings, and measurement tools used. Demographic characteristics covered the country where the research was conducted, participants' ages, and sample sizes. Analyzed domains of physical literacy included Social and Environmental Interaction (SEI), Knowledge and Understanding (K&U), Motivation and Confidence (M&C), Physical Competence (PC), and Total Physical Literacy (TPL). Effect sizes and standard deviations were calculated to enable an in-depth comparative analysis based on gender.

Statistical Analysis

In this review, statistical analysis was conducted using JASP (Version 0.18.3) by applying fixed and random effects models to evaluate the combined effect sizes of interventions on physical literacy. The fixed effects model was used when it was assumed that all studies shared the same effect, while the random effects model was used when effects varied among studies. Heterogeneity tests (Q and I^2) were used to assess variability between studies, which is crucial for understanding the extent to which these study results can be generalized. The Q test calculates the total variation expected across studies, whereas I^2 measures the proportion of total variation caused by heterogeneity.

Additionally, Funnel plot, Rank Correlation Test, and Egger's Test were employed to evaluate the potential for publication bias. The Funnel plot helps visualize the distribution of effect sizes among studies, and asymmetry in this plot can indicate the presence of publication bias. The Rank Correlation Test is used to detect asymmetry in the funnel plot by calculating the correlation between effect sizes and standard errors. Egger's Test provides an additional statistical test for asymmetry in the funnel plot, which may indicate publication bias.

Results

Literature Search and Screening Process

The literature search was completed on June 5, 2024, with an initial identification of 2,737 records in the Scopus database and 1,388 records in the PubMed database (see Figure 2). During the initial screening stage, 2,510 records from Scopus and 13 records from PubMed were removed because the search query did not appear in the title or abstract. Subsequently, 1,602 records from both databases met the criteria for further consideration.

In the advanced screening stage, 1,127 records were removed because they were not empirical research articles, 152 records were flagged as ineligible by automation tools for the years 2020-2024, 2 records were removed due to the lack of an abstract, and 15 records were removed for other reasons related to Scopus journal tier (Q1-Q4). Out of the initial 4,125 identified records, only 1,602 records were deemed eligible for further analysis. This screening process is crucial to ensure that only relevant and high-quality studies are analyzed, specifically those focusing on physical literacy in children and students.

Figure 1 shows a significant increase in the number of articles published in the Scopus and PubMed databases since 2018. During the early period up to 2010, the number of publications was relatively low and varied slightly each year. From 2011 to 2017, there was a more consistent increase, particularly in the PubMed database. A sharp increase has been observed since 2018, with the highest peak in 2023 for both databases, indicating growing interest and investment in research. Although there was a slight decline in 2024, the number of publications remains high, reflecting a positive trend in scientific publications, thus making this study viable. This analysis shows a clear and consistent upward trend in the number of publications, likely influenced by various factors such as increased research funding and encouragement from academic institutions.

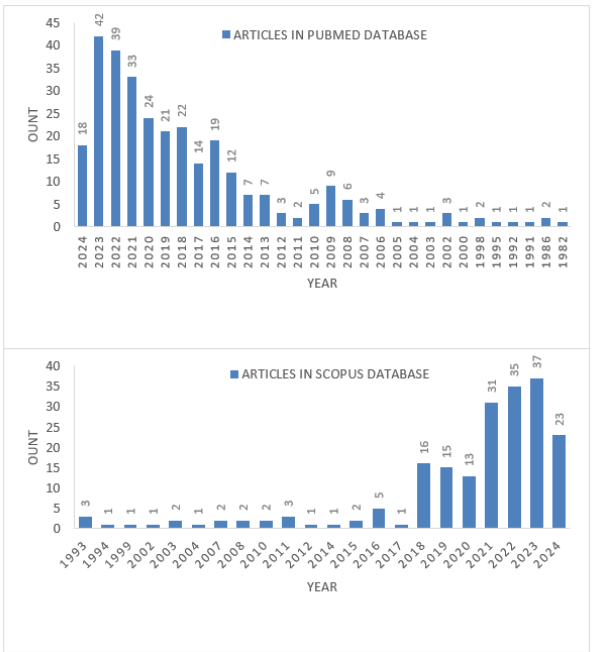

Figure 1. Distribution of Studies Post-Intervention in Two Databases

The screening process for these study records demonstrates systematic steps from initial screening to the identification of studies suitable for review. During the initial screening stage, a total of 306 records were screened, with 209 records excluded due to abstracts not aligning with the

topic, not being identified as suitable quantitative studies for meta-analysis, or having unclear gender comparisons. Subsequently, 97 reports were retrieved for full-text assessment, but 80 reports were not included due to being experimental and control studies that did not meet inclusion criteria, having inappropriate domains, or being identified as biased.

Following this, 17 reports were assessed for eligibility, and all these reports were included in the final review. Thus, out of the initial 306 records, only 17 studies were deemed eligible and included in the final analysis. This screening process ensures that only relevant and high-quality studies are analyzed, providing a robust foundation for a comprehensive and valid literature review.

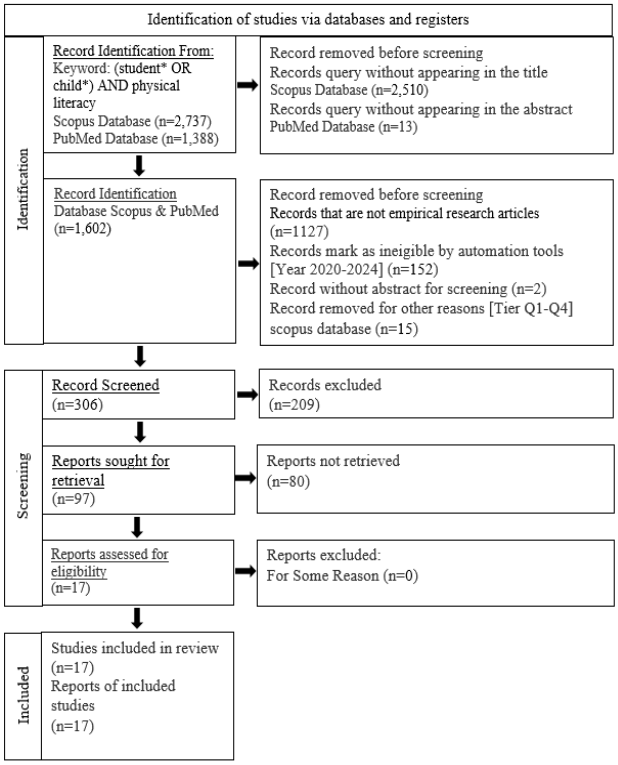

Figure 2. PRISMA Flow Diagram Illustrating the Study Identification and Selection Process

Table 2.
Summary of studies

Study	Study Design	Country	Age (Years)	Participant	Sample Size		PL Domains Addressed
					M	F	
(Geets-Kesić et al., 2023)	Cross-sectional preliminary	Croatia	16.8 ± 1.3	268 high school students	66	202	TPL
(Rajkovic Vuletic et al., 2024)	Cross-sectional	Croatia	9 and 11	107 primary schools	54	53	TPL
(Kesic et al., 2022)	Cross-sectional	Croatia	16.9 ± 1.4	253 high school students	72	181	K&U, M&C, PC
(Yan et al., 2023)	Cross-sectional	China	20.16 ± 1.21	1,980 junior-level college students	587	1,393	TPL
(Liu et al., 2024)	Cross-sectional	China	19.2 ± 1.2	798 college students	390	408	SEI, M&C, PC, TPL
(Li et al., 2020)	Cross-sectional	China	±10	327 primary students	153	174	SEI, PC, K&U, M&C, TPL
(Zhang et al., 2022)	Cross-sectional	China	±19.2	798 college students	390	408	SEI, PC, M&C,
(Long et al., 2024)	Correlational	China	±18.79	1,219 college students	733	486	SEI, K&U, TPL
(Ma et al., 2024)	Cross-sectional		18 to 25	969 college students	530	439	K&U
(Nezondet et al., 2023)	Observational	France	±12.1	85 high school students	53	32	TPL
(Jefferies et al., 2019)	Cross-sectional	Canada	9 to 12	221 primary school students	99	122	SEI, M&C, PC, TPL
(Mazzoli et al., 2024)	Cross-sectional	Australia	7 to 12	648 children	383	260	SEI, K&U, M&C, PC, TPL
(Caldwell et al., 2020)	Cross-sectional	Canada	±10.7	222 children	109	113	K&U, M&C, PC, TPL
(Barnett et al., 2022)	Observational	Australia	7 to 12	669 children at school	395	269	SEI, K&U, M&C, PC, TPL
(Urbano-Mairena et al., 2024)	Cross-sectional	Spain	8 to 12	135 children at school	62	71	K&U, PC, TPL
(Diao et al., 2024)	Observational	China	4 to 12	1,870 children	999	871	SEI, K&U, M&C, PC, TPL
(Dania et al., 2020)	Cross-sectional	Greece	8 to 12	576 children	268	308	K&U, M&C, TPL

TPL, Total Physical Literacy; K&U, Knowledge and Understanding; M&C, Motivation and Confidence; PC, Physical Competence; and SEI, Social and Environmental Interaction

Table 3.
Main Results of PL in Each Included Article Based on Their Measurements

Author	Type of PL	PL Measurement Tool	Main Findings
(Geets-Kesić et al., 2023)	PL	PLAYself Questionnaire	Weak correlation with GPA, higher in females
	Gender	Correlation and Cluster Analysis	Significant association in females, cluster shows higher GPA
	Statistical Methods	Pearson's Correlation, Cluster Analysis, Discriminant Canonical Analysis	Significant correlation in females, cluster shows GPA and PL/HL
(Rajkovic Vuletic et al., 2024)	PL	PLAYself Questionnaire	No significant association
	Statistical Methods	Pearson's Correlation, Two-way ANOVA, ICC, and t-test	Low to moderate significant correlation between PLAC and PAL in girls and fourth-grade students, significant for gender
(Kesic et al., 2022)	PL	PLAYself Questionnaire	Similar PL levels, significant correlation between PL and body composition only in males
	Statistical Methods	Pearson's Correlation, t-test	PL has a stronger relationship with male BC, except HL
(Yan et al., 2023)	PL	PPLI-SC	PL positively influences MVPA
	MVPA	IPAQ-SF	Higher MVPA in males compared to females
	Statistical Methods	Pearson Correlation, Linear Regression, t-tests, SPSS	PL positively influences MVPA and PAE
(Liu et al., 2024)	PL	PPL Instrument	Higher total PL in participants meeting PA guidelines and sedentary behavior
	Statistical Methods	Descriptive Analysis and Two-way ANOVA	Compliance with PA and SB guidelines correlates with higher total PL scores and related domains
(Li et al., 2020)	PPL	PPLI Instrument	Significant correlation between perceived and actual PL scores
	APL	CAPL-2, Accelerometers, Self-reported MVPA	Boys have higher actual PL scores compared to girls. Significant gender differences in Daily Behavior domain
	Statistical Methods	Pearson Correlation, MANOVA	Significant correlation ($r = 0.46$ for boys, $r = 0.41$ for girls) and significant differences in daily behavior based on gender ($p < 0.001$)
(Zhang et al., 2022)	PL	PPL Instrument Chinese Version	No significant gender differences in PL attributes
	Statistical Methods	Pearson Correlation, t-test	Significant differences in vital capacity, muscle strength, and aerobic fitness between men and women
(Long et al., 2024)	PPL	PPL Instrument Chinese Version	PPL and its dimensions significantly predict fitness test performance
	Statistical Methods	Separate Path Analysis by Gender	PPL and PAF Knowledge significantly predict fitness test performance
(Ma et al., 2024)	PL	Knowledge (Questionnaire score 0-7)	Students have a high level of knowledge about physical literacy
		Attitudes (Questionnaire score 9-45)	Moderate attitudes with concerns about the impact of the pandemic on studies and future
		Practices (Questionnaire score 10-50)	Negative practices, low participation in group exercises and psychological support
	Statistical Methods	Kolmogorov-Smirnov test, ANOVA, Mann-Whitney U-test, Kruskal-Wallis test, Pearson's correlation	Positive relationship between knowledge and attitudes, and attitudes and practices. Demographic factors influence KAP
(Nezondet et al., 2023)	PL	F-PPLI	PL significantly associated with %FM, %SMM, CRF, and MVPA
	Statistical Methods	Simple Linear Regression	PL negatively correlated with %FM and positively with %SMM, aerobic capacity, and MVPA. MVPA mediates some of these relationships
(Jefferies et al., 2019)	PL	PLAYtools	PL significantly correlates with resilience
	Resilience	CYRM	Resilience predicted by movement confidence, competence, environmental engagement, and overall PL
	Gender	Correlation and Logistic Regression Analysis	Males have higher movement competence and confidence than females
(Mazzoli et al., 2024)	PL	PL-C Quest	PL score associated with increased likelihood of meeting PA guidelines during COVID-19. PL subdomains also show significant associations
	Statistical Methods	Logistic Regression Analysis	Overall PL score and its subdomains significantly increase the likelihood of children meeting PA guidelines during COVID-19
(Caldwell et al., 2020)	PL	PLAYfun, PLAYself, PLAYparent	Physical literacy scores related to key health indicators
	Statistical Methods	Linear Regression Analysis	PL positively associated with aerobic fitness and HRQOL, and negatively with body fat percentage and systolic blood pressure
(Barnett et al., 2022)	PL	PL-C Quest	Good reliability and validity for children aged 7-12 years in Australia
	Statistical Methods	ICC, Cronbach's Alpha, CFA	PL-C Quest has good reliability and high internal consistency. CFA model shows adequate fit
(Urbano-Mairena et al., 2024)	PL	CAPL-2	Higher in children with normal weight compared to those overweight and obese
	Gender	Category: Male or Female	Males have higher PL, DB, PC, and MC compared to females
	Statistical Methods	Stepwise Linear Regression Test	PL positively associated with LS and negatively with BMI. Gender also significantly influences PL
(Diao et al., 2024)	PL	PL-C Quest	Demonstrates good validity and reliability in measuring PL in children aged 4-12 years in China across gender and age groups
	Statistical Methods	CFA WLSMV Approach	Good validity, internal consistency, and test-retest reliability
(Dania et al., 2020)	PL	CAMSA, PACER, Pedometer, and Questionnaire	Boys and older children show higher physical competence; high motivation across all age groups and genders
	Statistical Methods	CFA and ANOVA	Model fits the data and there are significant differences in PC and PAB behavior based on age and gender

PL, Physical Literacy; PLAYself Questionnaire, Physical Literacy Assessment for Youth self-reported Questionnaire; GPA, Grade Point Average; HL, Health Literacy; MVPA, Moderate to Vigorous Physical Activity; IPAQ-SF, International Physical Activity Questionnaire - Short Form; SPSS, Statistical Package for the Social Sciences; PAE, Physical Activity Engagement; PPL, Perceived Physical Literacy; PPLI, Perceived Physical Literacy Instrument; PPLI-SC, Perceived Physical Literacy Instrument - Simplified Chinese; CAPL-2, Canadian Assessment of Physical Literacy - Second Edition; APL, Actual Physical Literacy; %FM, Percentage of Fat Mass; %SMM,

Table 3.
Main Results of PL in Each Included Article Based on Their Measurements

Author	Type of PL	PL Measurement Tool	Main Findings

Percentage of Skeletal Muscle Mass; CRF, Cardiorespiratory Fitness; CYRM, Child and Youth Resilience Measure; HRQOL, Health-Related Quality of Life; ICC, Intraclass Correlation Coefficient; CFA, Confirmatory Factor Analysis; WLSMV, Weighted Least Squares Mean and Variance adjusted; CAMSA, Canadian Assessment of Movement Skills and Abilities; PACER, Progressive Aerobic Cardiovascular Endurance Run; PC, Physical Competence; PAB, Physical Activity Behavior; DB, Daily Behavior; LS, Life Satisfaction; KAP, Knowledge, Attitudes, and Practices; SB, Sedentary Behavior.

From the various studies presented in Table 3, it is evident that gender has a significant impact on physical literacy (PL). The study by Geets-Kesić et al. (2023) indicates a weak correlation between PL and GPA, but this correlation is higher among females. This study also found that females exhibited higher GPA in cluster analysis. Similarly, the study by Rajkovic Vuletic et al. (2024) found a low to moderate significant correlation between PLAC and PAL among girls and fourth-grade students. The research by Kesic et al. (2022) revealed that the PL levels were similar between men and women, but a significant correlation between PL and body composition was only found in men. This suggests that gender factors need to be considered in the analysis of physical literacy and related health indicators. The study by Urbano-Mairena et al. (2024) also confirmed that boys have higher scores in PL, physical competence (PC), and motor skills (MC) compared to girls.

Table 4.
Results of Effect Size and Standard Error Based on Gender and PL Domain in Each Included Article

Author	Domain	Domain in each inclusion article	Males			Females			Effect Size	Std. Dev
			N	Mean	SD	N	Mean	SD		
Liu et al., 2024	SEI	Interaction with the Environment	390	7.4	1.7	408	7.4	1.6	0	0.070817
Li et al., 2020	SEI	SE_PPL	153	11.9	2.7	174	11.9	2.1	0	0.110829
Zhang et al., 2022	SEI	Interaction with the environment	390	7.4	1.7	408	7.4	1.6	0	0.070817
Long et al., 2024	SEI	Interaction with the environment (PPL D3)	554	7.35	1.79	414	7.66	1.65	-0.17903	0.065093
Jefferies et al., 2019	SEI	Environmental engagement	99	24.4	3.4	122	23.9	3.3	0.146482	0.135448
Mazzoli et al., 2024	SEI	Social domain	383	13.2	2.7	260	13.4	2.6	-0.07519	0.080384
Barnett et al., 2022	SEI	Social domain	395	13.1	2.8	269	13.3	2.6	-0.07351	0.079077
Diao et al., 2024	SEI	Social	999	13.9	2.4	871	13.8	2.3	0.042482	0.046364
Kesic et al., 2022	SEI	PLAYself environment	68	50.86	15.23	198	51.16	15.43	-0.019506	0.14060
Long et al., 2024	K&U	Knowledge	519	94.68	8.22	395	96.64	5.3	-0.27577	0.067082
Kesic et al., 2022	K&U	PLAYself numeracy	68	60.06	21.3	198	61.07	22.7	-0.04519	0.140571
Ma et al., 2024	K&U	Knowledge	530	6.56	0.93	439	6.58	0.99	-0.02088	0.064536
Li et al., 2020	K&U	KU_CAPL2	153	5.6	2.4	174	5.8	2.3	-0.0852	0.110879
Long et al., 2024	K&U	Knowledge motivation (PPL D2)	553	12.82	1.66	413	13	1.4	-0.10295	0.065078
Mazzoli et al., 2024	K&U	Cognitive domain	383	22.4	4.5	260	22.3	4.3	0.022623	0.080359
Caldwell et al., 2020	K&U	PLAYself (relative rankings of literacies)	109	73.3	10.4	113	73.7	10.8	-0.03125	0.134261
Barnett et al., 2022	K&U	Cognitive domain	395	22.4	4.5	269	22.2	4.4	0.044845	0.079061
Urbano-Mairena et al., 2024	K&U	Knowledge and Understanding	62	6.47	1.82	71	6.42	1.58	0.029481	0.17383
Diao et al., 2024	K&U	Cognitive	999	24.4	3.9	871	24.1	3.6	0.079718	0.046377
Dania et al., 2020	K&U	Knowledge and understanding (8 years)	268	4.86	3.17	308	5.37	2.76	-0.17243	0.083689
Dania et al., 2020	K&U	Knowledge and understanding (9 years)	268	5.29	2.99	308	5.77	2.99	-0.16054	0.083669
Dania et al., 2020	K&U	Knowledge and understanding (10 years)	268	6.03	3.21	308	6.42	3.09	-0.12395	0.083615
Dania et al., 2020	K&U	Knowledge and understanding (11 years)	268	6.5	3.03	308	6.68	2.48	-0.06547	0.083557
Dania et al., 2020	K&U	Knowledge and understanding (12 years)	268	6.94	2.79	308	7.89	2.69	-0.3471	0.084159
Ma et al., 2024	K&U	Attitude	530	32.8	4.24	439	32.4	3.86	0.110503	0.064583
Kesic et al., 2022	M&C	PLAYself self-description	68	73.68	14.5	198	70.24	15.1	0.230527	0.140912
Liu et al., 2024	M&C	Motivation	390	12.1	1.9	408	12.1	1.7	0	0.070817
Li et al., 2020	M&C	SS_PPL	153	12.3	2.5	174	11.9	2.3	0.166972	0.111021
Li et al., 2020	M&C	MC_CAPL2	153	22.6	4.3	174	21.9	4.7	0.154959	0.110995
Zhang et al., 2022	M&C	Motivation	390	12.1	1.9	408	12.1	1.7	0	0.070817
Jefferies et al., 2019	M&C	PL self-description (Self-report)	99	33.94	4.96	122	33.44	5.59	0.094032	0.135343
Mazzoli et al., 2024	M&C	Psychological domain	383	21.9	4.5	260	21.6	4.3	0.067869	0.080378
Caldwell et al., 2020	M&C	PLAYparent (confidence)	109	129	16.1	113	127	15.9	0.10869	0.134352
Barnett et al., 2022	M&C	Psychological domain	395	21.9	4.5	269	21.5	4.4	0.08969	0.07909
Diao et al., 2024	M&C	Psychological	999	23.8	3.9	871	23.3	3.8	0.129744	0.046407
Dania et al., 2020	M&C	Motivation and confidence (8 years)	268	25.9	4.03	308	25.8	3.5	0.029288	0.083539
Dania et al., 2020	M&C	Motivation and confidence (9 years)	268	26.4	3.14	308	25.5	3.82	0.275563	0.083929
Dania et al., 2020	M&C	Motivation and confidence (10 years)	268	26.7	2.43	308	26.4	2.59	0.107277	0.083595
Dania et al., 2020	M&C	Motivation and confidence (11 years)	268	26.3	3.15	308	25.9	3.05	0.119474	0.083609
Dania et al., 2020	M&C	Motivation and confidence (12 years)	268	26.4	1.76	308	26.2	2.77	0.055208	0.083551
Liu et al., 2024	PC	Confidence and Physical Competence	390	11.3	2.2	408	11.4	2	-0.04762	0.070827
Li et al., 2020	PC	PC_CAPL2	153	17.6	5.6	174	17.1	4.4	0.100055	0.110898
Zhang et al., 2022	PC	Confidence and physical competence	390	11.3	2.2	408	11.4	2	-0.04762	0.070827
Jefferies et al., 2019	PC	Movement competence (Trained assessor)	99	33.44	7.17	122	30.76	7.39	0.367507	0.136394
Jefferies et al., 2019	PC	Movement competence (Parent)	99	16.37	2.85	122	15.31	2.1	0.430195	0.136808
Jefferies et al., 2019	PC	Movement competence (PE teacher)	99	24.74	6.72	122	23.77	5.98	0.153436	0.135466
Mazzoli et al., 2024	PC	Physical domain	383	37.1	7.2	260	35.5	7.2	0.222222	0.080595
Caldwell et al., 2020	PC	PLAYfun (movement skills)	109	50.3	7.82	113	47.9	7.13	0.31966	0.135107
Barnett et al., 2022	PC	Physical domain	395	37	7.2	269	35.4	7.3	0.220975	0.079284
Urbano-Mairena et al., 2024	PC	Physical competence	62	17.2	6.03	71	14.6	5.06	0.478955	0.176284
Diao et al., 2024	PC	Physical	999	37.8	7.1	871	36.5	6.7	0.187954	0.04646

Table 4.
Results of Effect Size and Standard Error Based on Gender and PL Domain in Each Included Article

Author	Domain	Domain in each inclusion article	Males			Females			Effect Size	Std. Dev
			N	Mean	SD	N	Mean	SD		
Geets-Kesić et al., 2023	TPL	Physical literacy	66	68.1	11	202	68	11.4	0.001773	0.141782
Vuletic et al., 2024	TPL	Playself (Third Grade)	27	71.6	13.3	25	73.1	10.7	-0.12056	0.277807
Vuletic et al., 2024	TPL	PLAYself (Fourth Grade)	27	75.2	8.69	28	73.6	11	0.162159	0.270167
Kesic et al., 2022	TPL	PLAYself physical literacy	68	82.6	18	198	86.6	19.5	-0.20993	0.140852
Kesic et al., 2022	TPL	PLAYself total	68	68.1	11	198	68	11.4	0.001773	0.140557
Yan et al., 2023	TPL	Physical literacy	587	32	6.43	1393	29.2	5.21	0.498284	0.049841
Liu et al., 2024	TPL	PL overall	390	30.6	4.2	408	30.9	4	-0.07319	0.070841
Li et al., 2020	TPL	PPL	153	37.3	6.5	174	36.5	5.6	0.132502	0.11095
Li et al., 2020	TPL	CAPL2	153	58.9	11	174	55.1	9.8	0.366141	0.11175
Long et al., 2024	TPL	PPL total	553	31.5	4.66	413	32.4	4.07	-0.206	0.065204
Nezondet et al., 2023	TPL	Perceived physical literacy	53	37.2	5.7	32	38.8	4.7	-0.29915	0.225043
Jefferies et al., 2019	TPL	Overall rating	99	23.29	4.03	122	22.79	3.06	0.141756	0.135437
Jefferies et al., 2019	TPL	Overall rating	99	4.27	1.77	122	4.1	1.7	0.098171	0.13535
Mazzoli et al., 2024	TPL	Overall score	383	94.6	16.4	260	92.7	16.2	0.116425	0.080422
Caldwell et al., 2020	TPL	Physical literacy composite	109	0.22	2.33	113	-0.22	2.05	0.200736	0.134591
Barnett et al., 2022	TPL	Overall physical literacy	395	94.3	16.6	269	92.5	16.5	0.108698	0.079108
Urbano-Mairena et al., 2024	TPL	CAPL-2	62	70.9	12.2	71	60.1	11.1	0.937006	0.183069
Diao et al., 2024	TPL	Overall	999	99.8	14.7	871	97.7	13.7	0.147441	0.046421
Dania et al., 2020	TPL	Total CAPL-2 (8 years)	268	55.7	12.4	308	56	10.8	-0.02597	0.083539
Dania et al., 2020	TPL	Total CAPL-2 (9 years)	268	63.8	11.6	308	56.4	9.18	0.715932	0.086157
Dania et al., 2020	TPL	Total CAPL-2 (10 years)	268	64.8	11.1	308	64.8	10.8	0.001826	0.083535
Dania et al., 2020	TPL	Total CAPL-2 (11 years)	268	67	11.1	308	64.3	11.5	0.240832	0.083836
Dania et al., 2020	TPL	Total CAPL-2 (12 years)	268	75.8	10.4	308	68.3	11.2	0.690559	0.085977

TPL, Total Physical Literacy; K&U, Knowledge and Understanding; M&C, Motivation and Confidence; PC, Physical Competence; and SEI, Social and Environmental Interaction

The data provided indicates gender variation in domains such as physical competence, knowledge, and motivation. Overall, the differences between males and females are generally small across most domains, with balanced effect sizes, particularly in knowledge and environmental engagement. However, in some areas like physical competence, males show a more significant advantage. These findings suggest that targeted interventions may be needed to address gender gaps in the development of physical literacy skills.

Table 5.
Meta-Analysis for Fixed and Random Effects and Publication Bias Test in Various Domains

Category	Fixed and Random Effects						Coefficients (intercept)						Rank correlation test for Funnel plot asymmetry		Egger's test	
	Omnibus			Residual			Estimate	Std. Error	z	p	95% CI		Kendall's	p	z	p
Domains	Q	df	p	Q	df	p					Lower	Upper	τ			
SIE	0.944	1	0.331	10.388	8	0.239	-0.024	0.025	-0.972	0.331	-0.073	0.025	-0.086	0.752	0.007	0.994
K&U	8.486	1	0.004	45.829	15	<0.001	-0.057	0.019	-2.913	0.004	-0.095	-0.019	-0.267	0.165	-1.809	0.07
M&C	21.385	1	<0.001	11.483	14	0.648	0.098	0.021	4.624	<0.001	0.057	0.14	0.404	0.037	0.598	0.55
PC	35.034	1	<0.001	29.832	10	<0.001	0.153	0.026	5.919	<0.001	0.102	0.203	0.519	0.028	2.415	0.016
TPL	101.172	1	<0.001	212.549	22	<0.001	0.188	0.019	10.058	<0.001	0.151	0.224	0.036	0.835	-1.506	0.132

Domain Social and Environmental Interaction (SEI)

This meta-analysis evaluates physical literacy in the domain of social and environmental interaction through the analysis of various studies. The Funnel Plot (see Figure 3) presented shows a symmetrical distribution of effects, indicating no significant publication bias. This result is supported by Kendall's τ of -0.086 with a p-value of 0.752, confirming the absence of significant asymmetry.

The Forest Plot illustrates (see Figure 3) the results from various studies, where the study by Long et al. (2024) shows a significant negative effect (-0.18 [-0.31, -0.05]), and the study by Jeffries et al. (2019) shows a significant positive effect (0.15 [-0.12, 0.41]). Other studies, such as those by Liu et al. (2024), Li et al. (2020), Zhang et al. (2022), Mazzoli et al. (2024), Barnett et al. (2022), Diao et al. (2024), and Kesic et al. (2022), do not show statistically significant effects.

Statistically, the Omnibus Test of Model Coefficients indicates that the overall model coefficients are not significant, with a Q-value of 0.944, df=1, and p=0.331. The residual heterogeneity test shows a Q-value of 10.388, df=8, and p=0.239, indicating that the heterogeneity among studies is not significant. Furthermore, the Rank Correlation Test and Egger's Test show no significant publication bias, with Kendall's τ of -0.086 (p=0.752) and z=0.007 (p=0.994) respectively. Most studies did not show statistically significant effects, except for two studies that showed significant effects in opposite directions. The absence of significant publication bias and insignificant heterogeneity strengthens the validity of this meta-analysis.

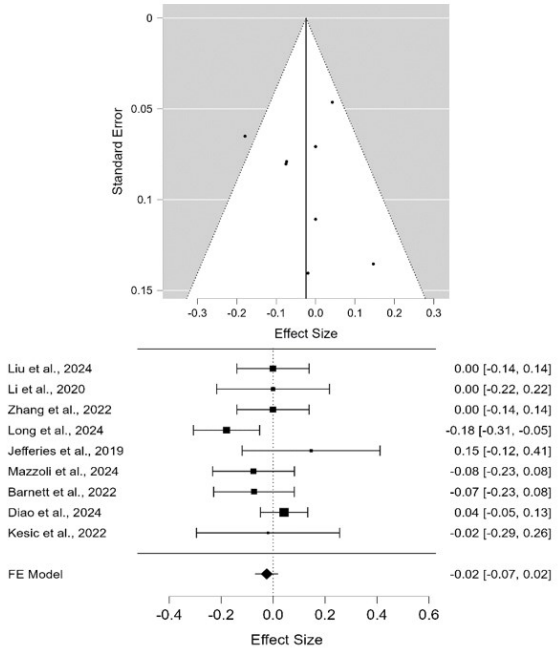

Figure 3. Forest Plot Accompanied by Funnel Plot for SEI

Domain Knowledge and Understanding (K&U)

This meta-analysis evaluates the Knowledge and Understanding (K&U) domain by analyzing a number of relevant studies. The funnel plot (see figure 4) shows the distribution of standard error against the effect size of these studies. The relatively symmetrical distribution in the funnel plot suggests that publication bias is likely insignificant, with points evenly dispersed around the vertical line representing the overall effect.

The forest plot (see figure 4) illustrates the individual results of each study as well as the overall effect. The effect sizes of these studies range from -0.35 to 0.11, with the majority of studies showing non-significant results. The fixed-effect model indicates a combined effect size of -0.06 [CI: -0.09, -0.02], suggesting a small but significant negative effect on K&U in the domain of Physical Literacy. Further model statistics show that a Q value of 8.486 with a p-value of 0.004 in the Omnibus Test of Model Coefficients indicates that the overall model coefficients are significant.

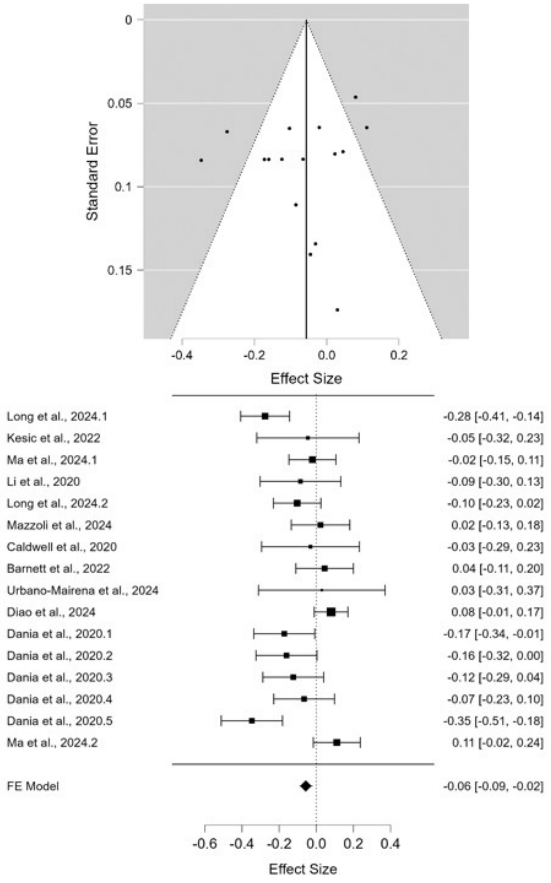

Figure 4. Forest Plot Accompanied by Funnel Plot for K&U

The residual heterogeneity test, with a Q value of 45.829 and a p-value of < 0.001, indicates significant variability among the analyzed studies, suggesting notable heterogeneity. Additional analysis with the Rank Correlation Test yields a Kendall's τ value of -0.267 with a p-value of 0.165, indicating no significant correlation between effect size and standard error, supporting the assumption of no significant publication bias. Egger's Test, with a z value of -1.809 and a p-value of 0.070, also supports the conclusion that publication bias is not significant.

Motivation and Confidence (M&C)

Based on the meta-analysis data related to the M&C domain in physical literacy, several key findings can be interpreted. The funnel plot in Figure 5, used to assess potential publication bias, shows slight asymmetry, with some points more distributed on the right side. This indicates the possibility of publication bias. The Rank Correlation Test results (Kendall's $\tau = 0.404$, $p = 0.037$) support the indication of significant asymmetry, while Egger's test ($z = 0.598$, $p = 0.550$) does not show significant results, overall suggesting the presence of publication bias, albeit not very strong.

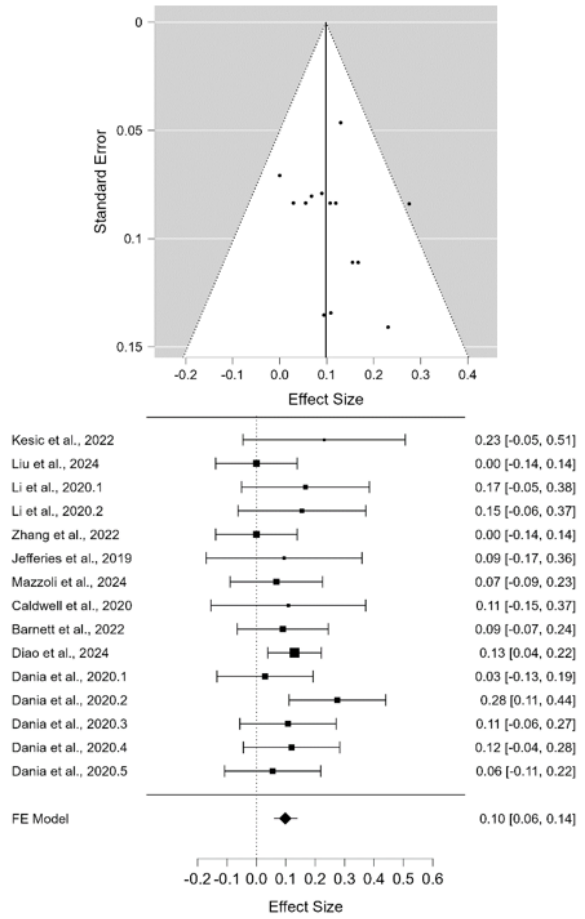

Figure 5. Forest Plot Accompanied by Funnel Plot for M&C

The forest plot (see Figure 5) shows the effect sizes from various studies included in the meta-analysis. The results of individual studies vary, for example, Kesic et al. (2022) show an effect size of 0.23 [95% CI: -0.05, 0.51], whereas Liu et al. (2024) show an effect size of 0.00 [95% CI: -0.14, 0.14]. The combined effect size using the fixed-effect model shows a value of 0.10 [95% CI: 0.06, 0.14], which is statistically significant ($p < 0.001$). This indicates a small but consistent effect regarding motivation and confidence in physical literacy.

Heterogeneity analysis shows significant variation among individual studies ($Q = 21.385$, $p < 0.001$). However, after accounting for fixed effects, residual heterogeneity is not significant ($Q = 11.483$, $df = 14$, $p = 0.648$), indicating consistency among studies after applying the fixed-effect model. Overall, these findings suggest that despite variation among individual studies and potential publication bias, the combined effect indicates a small but significant positive relationship between motivation and confidence with physical literacy.

Physical Competence (PC)

A meta-analysis conducted to evaluate the impact of interventions on physical competence demonstrated significant results. Based on the funnel plot shown in Figure 6, a slight asymmetry is observed, indicating the potential presence of publication bias. However, this asymmetry is not substantial enough to undermine the overall reliability of the study results.

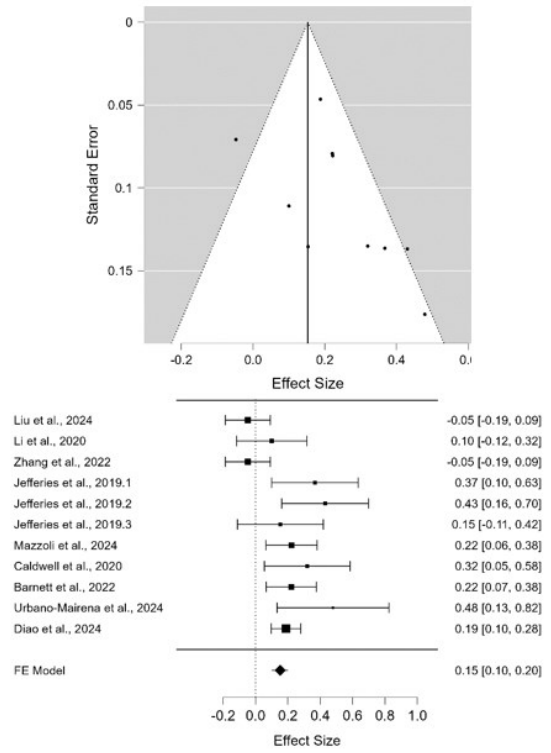

Figure 6. Forest Plot Accompanied by Funnel Plot for PC

The forest plot (see Figure 6) illustrates the variation in effect sizes across different studies, with a combined effect estimate of 0.15 [0.10, 0.20], indicating that the interventions have a moderate and significant impact on physical competence. Further statistical tests revealed that the model used has statistically significant coefficients, with a Q value of 35.034 and $p < 0.001$.

Additionally, the residual heterogeneity test indicated significant heterogeneity among the analyzed studies ($Q = 29.832$, $df = 10$, $p < 0.001$). This suggests that the effects of the interventions vary across studies. Kendall's τ test and Egger's test both indicated a slight publication bias, but the statistical significance of this bias is not high enough to be considered substantial. Overall, it can be concluded that the analyzed interventions have a significant and moderate effect on individuals' physical competence. Despite the heterogeneity among studies, these results consistently show that programs aimed at enhancing physical competence provide tangible benefits.

Total Physical Literacy (TPL)

Based on the conducted meta-analysis, it can be concluded that the analyzed interventions overall have a significantly positive effect on physical literacy. The funnel plot analysis shows a symmetric distribution of individual studies, with a Kendall's τ value of 0.036 and a p-value

of 0.835, as well as Egger's test results indicating a z-value of -1.506 and a p-value of 0.132. This suggests that there is no significant publication bias in this meta-analysis.

The forest plot shows an overall effect size of 0.19 [0.15, 0.22], illustrating the significant positive effect of the interventions on physical literacy. However, there is significant heterogeneity in the data, as indicated by the Omnibus test of Model Coefficients ($Q = 101.172$, $df = 1$, $p < 0.001$) and the Test of Residual Heterogeneity ($Q = 212.549$, $df = 22$, $p < 0.001$). Nevertheless, the majority of studies demonstrate positive effects, with some standout studies such as Yan et al. (2023) showing an effect size of 0.50 [0.40, 0.60] and Dania et al. (2020) with an effect size of 0.69 [0.52, 0.86].

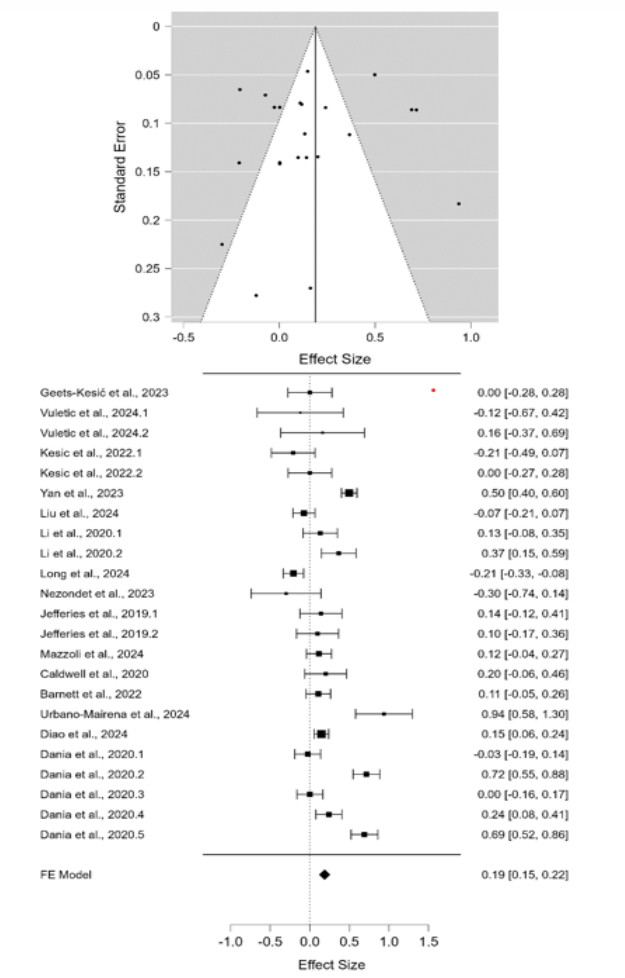

Figure 7. Forest Plot Accompanied by Funnel Plot for TPL

Discussion

This study aims to conduct a systematic literature review (SLR) and meta-analysis on physical literacy (PL) with a focus on gender comparisons among school-aged children and adolescents. Considering the multi-dimensional nature of the PL concept, we examined the impact of interventions across different yet interrelated PL domains: Social and Environmental Interaction (SEI), Knowledge and Understanding (K&U), Motivation and Confidence (M&C), Physical Competence (PC), and Total Physical Literacy (TPL). This discussion integrates findings from various studies presented in this analysis to provide a comprehensive understanding of the effects of PL interventions based on gender.

The results from various analyzed studies indicate that there is no significant overall effect of interventions on the SEI domain. Liu et al. (2024) and Li et al. (2020) reported small or non-significant effect sizes (Li et al., 2020; Liu et al., 2024). Long et al. (2024) even demonstrated a significantly negative effect, which might be attributed to differences in measurement methods and the social contexts of the respective studies (Long et al., 2024). This variability in results suggests that social and environmental interactions are heavily influenced by external factors and the methods employed. In the context of gender, males tend to have more active social interactions compared to females; however, the differences are not statistically significant (Liu et al., 2024; Li et al., 2020; Long et al., 2024).

In the K&U domain, the results indicate that there is a small but significant effect that is more dominant in females. Long et al. (2024) reported a small negative effect, while Mazzoli et al. (2024) showed nearly neutral results (Mazzoli et al., 2024; Long et al., 2024). Studies that showed significant results utilized more interactive and in-depth teaching methods, whereas studies with non-significant results employed more traditional and less effective approaches (Edwards et al., 2017; Cairney et al., 2019). Females tend to show better outcomes in the K&U domain compared to males, although the differences are not statistically significant in most studies (Mazzoli et al., 2024; Edwards et al., 2017).

Analysis in the M&C domain shows a small but significant positive relationship between motivation and confidence with physical literacy. Kesic et al. (2022) and Li et al. (2020) reported significant effect sizes (Kesic et al., 2022; Li et al., 2020). Motivation and confidence are often influenced by psychosocial factors that can be targeted through well-designed programs. Studies showing significant results typically involve interventions that focus on enhancing students' intrinsic motivation and confidence through social support and individual achievement recognition (Cairney et al., 2019; Durden-Myers et al., 2018). Females tend to show more significant improvements in motivation and confidence compared to males, which may be due to their more responsive approach to social support (Kesic et al., 2022; Li et al., 2020; Cairney et al., 2019).

Interventions in the PC domain demonstrate a moderate and significant impact on physical competence. Jefferies et al. (2019) and Barnett et al. (2022) reported significant effects. Programs that directly focus on enhancing students' motor skills and physical activity provide intensive and structured physical training, resulting in significant improvements in physical competence. From a gender perspective, males tend to show more significant improvements in physical competence compared to females, which may be attributed to males' tendency to engage in more intensive and competitive physical activities (Jefferies et al., 2019; Barnett et al., 2022;

Urbano-Mairena et al., 2024; Chaeroni et al., 2024).

The TPL domain shows a significant positive effect of interventions on overall physical literacy. Yan et al. (2023) and Dania et al. (2020) reported large effect sizes (Yan et al., 2023; Dania et al., 2020). The holistic nature of the interventions, encompassing various aspects of physical literacy, from knowledge and understanding to physical competence and confidence, makes comprehensive and sustained interventions more effective in enhancing overall physical literacy. Females tend to show more significant improvements in overall physical literacy compared to males, which may be due to the more holistic and responsive approach to individual needs within these programs (Yan et al., 2023; Dania et al., 2020; Chaeroni et al., 2024; Urbano-Mairena et al., 2024).

The meta-analysis for the SEI domain indicates no overall significant effect, supporting findings from previous studies. The meta-analysis for the K&U domain shows a small but significant effect, reflecting varied results based on teaching approaches. The meta-analysis for the M&C domain reveals a small but significant positive relationship, supporting the finding that interventions focusing on psychosocial factors are effective in enhancing students' motivation and confidence. The meta-analysis for the PC domain indicates a moderate and significant effect, supporting the finding that approaches focusing on specific motor skills are effective in improving physical competence. The meta-analysis for TPL demonstrates a significant positive effect, underscoring the importance of a holistic approach in physical literacy programs (Mazzoli et al., 2024; Long et al., 2024; Yan et al., 2023; Dania et al., 2020). Overall, this study shows that physical literacy interventions have significant effects across various domains of physical literacy, with some differences based on gender. These findings provide critical evidence for the development of more inclusive and gender-equitable physical education programs. The results also highlight the importance of considering contextual and methodological factors in physical literacy analysis to address gender disparities in the development of physical literacy among children and adolescents. Well-designed programs that take into account gender differences and contextual factors can yield more effective and sustainable outcomes. Key limitations of this study include the heterogeneity across studies, the lack of data from developing countries, and potential publication bias, although not statistically significant. Furthermore, the absence of longitudinal data limits the understanding of the long-term effects of physical literacy interventions. Future research should expand the analysis to include more diverse socio-cultural contexts and comprehensive longitudinal data. Thus, this research provides a strong foundation for further development, particularly in exploring physical literacy (PL) interventions tailored to gender needs and more diverse socio-cultural contexts. Future studies are encouraged to include more extensive longitudinal analyses and consider other variables that may influence outcomes, such as socio-economic background and students' mental health status.

Conclusion

This study conducted a systematic review and meta-analysis to evaluate physical literacy (PL) with a focus on gender comparisons among school-aged and college students. The results indicate that PL interventions have significant effects across various PL domains, with some differences based on gender. Specifically, the Social and Environmental Interaction (SEI) domain shows no overall significant effect, while the Knowledge and Understanding (K&U) and Motivation and Confidence (M&C) domains show small but significant effects, with females tending to show better outcomes. The Physical Competence (PC) domain shows a moderate and significant impact, with males tending to exhibit greater improvements. The Total Physical Literacy (TPL) domain demonstrates a significant positive effect, emphasizing the importance of a holistic approach in PL interventions. These findings provide critical evidence for the development of more inclusive and gender-equitable physical education programs and highlight the importance of considering contextual and methodological factors in physical literacy analysis. Thus, this study contributes to promoting gender equality and improving the quality of physical education in schools and colleges, while also providing insights for more effective long-term health strategies.

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Datos de los/as autores/as y traductor/a:

Ahmad Chaeroni	ahmad.chaeroni@fik.unp.ac.id	Autor/a
Muchamad Arif Al Ardha	muchamadalardha@unesa.ac.id	Autor/a
Lutfi Nur	lutfinur@upi.edu	Autor/a
Mottakin Ahmed	mottakin460@gmail.com	Autor/a
Kamal Bin Talib	kamaa@umt.edu.my	Autor/a
Bekir Erhan Orhan	bekirerhanorhan@aydin.edu.tr	Autor/a
Mert Kurnaz	mertkurnaz@halic.edu.tr	Autor/a
Shamsudin Yassin	mathsproofread@gmail.com	Traductor/a