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REVIEW

Physical Education's Role in Enhancing Fitness Among Children and Adolescents: A Bibliometric Analysis

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Introduction: Physical education (PE) is a key school-based strategy for improving physical fitness (PF) among children and adolescents. However, a systematic synthesis of the most influential literature linking PE to PF development remains limited. Understanding publishing patterns and research hotspots can inform future directions in PE- and PF-related scholarship.

Objective: To conduct a bibliometric analysis of the 50 most-cited articles examining the relationship between PE and PF in school-aged children and adolescents, and to identify major contributors, thematic clusters, and evidence gaps.

Methods: A comprehensive search was performed using the Web of Science Core Collection. The 50 most-cited articles meeting the inclusion criteria were analyzed. Citation patterns, journal productivity, country contributions, co-authorship networks, and keyword co-occurrence were examined using Microsoft Excel and VOSviewer. Quantitative indicators—including total citations, citations per paper (CPP), and cluster mapping—were summarized.

Results: The included articles received 52–687 citations. The United States produced the highest number of publications (n = 19; CPP = 100.3), followed by Australia and Spain (each n = 6). The most active journals were BMC Public Health (5 articles, 481 citations) and PLOS ONE (4 articles, 582 citations). Keyword analyses identified three major thematic clusters: (1) PE-based interventions, (2) health-related fitness components (aerobic capacity, muscular strength, body composition), and (3) cognitive and psychological outcomes linked to PE participation. Across studies, PE consistently improved multiple PF dimensions among children and adolescents.

Conclusion: High-impact evidence shows that well-designed school-based PE programs significantly enhance aerobic fitness, muscular strength, body composition, and overall health-related PF in youth—while also providing emerging cognitive and psychosocial benefits. However, research output remains heavily concentrated in high-income countries, indicating a need for more diverse and equitable global investigations. This bibliometric synthesis clarifies current research patterns and highlights opportunities for advancing evidence-based PE to support youth fitness development.

Keywords: adolescent, child, citation, physical fitness, VOSviewer, visualization

Introduction

Physical fitness (PF) is widely recognized as a critical biomarker of health status and developmental integrity in children and adolescents.[1–3] As a multidimensional construct, PF encompasses cardiorespiratory endurance, muscular strength, muscular endurance, flexibility, and body composition[4–6]—domains that collectively reflect the functional capacity of the metabolic, musculoskeletal, and neuromotor systems.[7,8] Robust epidemiological and experimental evidence has demonstrated that higher PF levels in youth are associated with healthier adiposity profiles, improved cardiometabolic markers, greater motor competence, and more favorable psychological and cognitive outcomes.[1,9] Conversely, low PF during childhood and adolescence is linked to increased risks of obesity, metabolic dysfunction, and reduced quality of life, with potential consequences extending into adulthood.[10–12] Given the rapid and dynamic biological and psychosocial transitions that characterize these developmental stages, tracking PF trends and understanding the scientific landscape

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surrounding youth fitness is essential for informing prevention strategies and public health policy. Despite growing research activity, no prior bibliometric synthesis has systematically examined the most influential studies on physical fitness among children and adolescents, leaving an important gap in understanding how the field has developed, which themes dominate current evidence, and where critical knowledge deficits persist. Addressing this gap through a comprehensive bibliometric analysis can provide valuable insights into research patterns, methodological emphases, and future priorities in pediatric fitness scholarship.

Physical education (PE) at school involves group participation for children and adolescents.[2,13–15] Packham and Street (2019)[16] pointed out that regular organization of PE in schools and its planning into the total curriculum can provide teenagers with professional physical knowledge, to ensure the effectiveness of fitness promotion methods. PE plays an important role in regulating teenagers' emotions and cultivating lifelong sports consciousness.[17,18] At the social level, PE can help students build good interpersonal relationships and adopt positive attitudes and coping measures in the face of pressure.[19] Starc and Strel (2021)[20] define quality PE as exercise suitable for teenagers' load. Based on experimental comparisons of different exercise intensities among primary school students, previous research has shown that teachers can regulate exercise intensity—for example, by adjusting activity type, duration, and movement tempo—to help maintain students' heart rates within an optimal range (approximately 129–151 beats per minute),[21] which is associated with long-term improvements in body mass index. Moderate-intensity physical education can play an important role in helping schools identify early signs of psychological difficulties among adolescents, allowing timely referral and intervention to support students' physical and mental well-being.[22] In addition, Qin et al,[23] examining the context of physical education in China, reported that the quality of PE in many schools remains insufficient to promote youth health meaningfully. They emphasized that improving PE effectiveness requires not only experimenting with diverse exercise formats but also integrating relevant health education—such as nutrition and weight-management knowledge—to address factors closely linked to adolescents' overall health.

Bibliometrics refers to a discipline that studies communication and publishing patterns using statistical techniques in information distribution,[24] to gain an in-depth understanding of specific research courses and processes.[25] Through bibliometric research, scholars can analyze and monitor their research field of interest. By conducting bibliometric research, administrators, policymakers, and organizations can make informed decisions based on quantitative indicators to allocate resources and promote research.[26,27] Therefore, with increasing output in physical education and physical fitness, bibliometrics becomes a valuable tool for determining collaboration patterns, topics represented, publishing trends, and important institutions or authors.

At present, there is a lack of research on the development of physical education and the corresponding impact assessment on students' fitness, and there is no set systematic assessment system.[28] The purpose of this study is to further explore the necessity of physical education and point out the unreasonableness of existing policies, to provide persuasive suggestions for managers and policymakers.

Materials and Methods

Study Design and Search Strategy

Prior bibliometric research of the most-cited papers on physical activity informed the methodology.[29] As this study included neither human nor animal subjects, it was excluded from the need for a formal ethical review. On 13th November 2025, we conducted a literature search in the Web of Science Core Collection (WoSCC), a data knowledge platform covering plenty of leading journals across hundreds of disciplines in the health sciences, social sciences, and humanities. More specifically, four indices from WoSCC were utilised: the Science Citation Index Expanded (SCIE), the Social Sciences Citation Index (SSCI), the Arts & Humanities Citation Index (AHCI), and the Emerging Sources Citation Index (ESCI). These were employed to retrieve documents published from the inception of the database up to 13th November 2025. The selection of these four indices is due to their relevance to the topic of this study, coverage of high-quality publications, and widespread use in bibliometric studies.[30] Indeed, other similar large databases, such as Scopus and Google Scholar, can be used to perform bibliometric analyses. However, merging different databases may introduce

additional biases.[31] In addition, previous research shows WoSCC is able to identify the essential information (eg, authors, nations, and keywords related to each publication) for the bibliometric analysis.[32]

The records were accessed using the Changchun University of Technology Library's online connection to the WoSCC and retrieved using an advanced search based on the concept of physical education and physical fitness in the following term combinations: TS = ("physical education" OR "school-based exercise" OR "school-based physical activity" OR "school-based physical exercise" OR "school-based sport") AND TS = ("physical fitness" OR "aerobic fitness" OR "cardiorespiratory fitness" OR "muscular fitness" OR "physical endurance" OR "muscular strength" OR "muscular endurance" OR "muscular resistance" OR "flexibility" OR "motor fitness" OR "functional fitness") AND TS = (child OR adolescent OR youth OR student) NOT TS = (adult OR university OR colleague).

Publication Selection and Data Extraction

After searching the four indices from WoSCC, a total of 1440 articles were retrieved after the first search. Then, the eligibility of each piece was verified by having two authors independently examine the titles and abstracts. The inclusion criteria were: 1) Empirical study; 2) Published in English; 3) Population should be children and adolescents; 4) Intervention should be physical education; 5) Outcome should be fitness-related. Review articles and empirical articles that focus on adults, university, and college students will be excluded. In the case that there were any disagreements, they were resolved with the assistance of a senior author. Figure 1 depicts a flowchart of the publication selection and data extraction processes.

Data Analysis and Visualization

Data from the Web of Science Core Collection was imported into Microsoft Excel for descriptive analysis. The data included author names, years, nations, journals, and institutions. Java-based VOSviewer is a bibliometric network analysis program that can scan thousands of articles from academic journals to build unimodal undirected networks of publishing trends. On the basis of mathematical statistics and computer technology, VOSviewer provides the possibility to present the data in a graphical way, effectively guiding academics and professionals to better understand scientific research in the field of physical education and physical fitness. This study used VOSviewer to perform a co-authorship analysis and a co-occurrence analysis of keywords for exploring research characteristics, topics, and hotspots.

Results

A total of 50 articles have reviewed physical education and physical fitness according to our screening, which are shown in Table 1. The number of total citations ranged from 52 to 687.

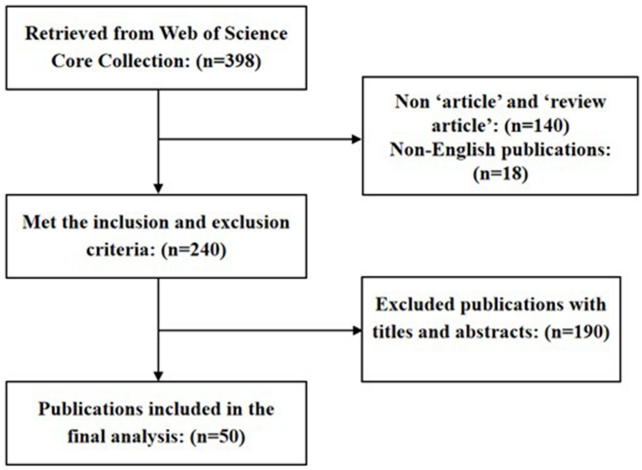

Figure 1 The flow chart.

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Table 1 List of Included Papers

Rank	Authors	Year	Title	Journal	Total Citations
1	Kriemler, S	2010	Effect of school based physical activity programme (KISS) on fitness and adiposity in primary schoolchildren: cluster randomised controlled trial	BMJ-British Medical Journal	372
2	Telford, R. M.	2016	Why Are Girls Less Physically Active than Boys? Findings from the LOOK Longitudinal Study	PLOS ONE	325
3	Barnett, L. M.	2008	Perceived sports competence mediates the relationship between childhood motor skill proficiency and adolescent physical activity and fitness: a longitudinal assessment	International Journal of Behavioral Nutrition and Physical Activity	324
4	Schmidt, M.	2015	Cognitively Engaging Chronic Physical Activity, But Not Aerobic Exercise, Affects Executive Functions in Primary School Children: A Group-Randomized Controlled Trial	Journal of Sport & Exercise Psychology	234
5	Carrel, A.L.	2005	Improvement of fitness, body composition, and insulin sensitivity in overweight children in a school-based exercise program - A randomized, controlled study	Archives of Pediatrics & Adolescent Medicine	216
6	Ardoy, D.N.	2014	A Physical Education trial improves adolescents' cognitive performance and academic achievement: the EDUFIT study	Scandinavian Journal of Medicine & Science in Sports	175
7	Crova, C.	2014	Cognitively challenging physical activity benefits executive function in overweight children	Journal of Sports Sciences	144
8	Flores, R.	1995	Dance for health - improving fitness in African-American and Hispanic adolescents	Public Health Reports	136
9	Hansen, H.S.	1991	A controlled-study of 8 months of physical-training and reduction of blood-pressure in children - the Odense schoolchild study	British Medical Journal	127
10	Naylor, P-J.	2006	Lessons learned from Action Schools! BC - An "active school" model to promote physical activity in elementary schools	Journal of Science and Medicine in Sport	126
11	Bonhauser, M.	2005	Improving physical fitness and emotional well-being in adolescents of low socioeconomic status in Chile:: results of a school-based controlled trial	Health Promotion International	124
12	Ara, I.	2004	Regular participation in sports is associated with enhanced physical fitness and lower fat mass in prepubertal boys	International Journal Of Obesity	122
13	Zahner, L.	2006	A school-based physical activity program to improve health and fitness in children aged 6–13 years (Kinder-Sportstudie KISS):: study design of a randomized controlled trial [ISRCTN15360785]	BMC Public Health	116
=14	Chen, W.	2018	Health-related physical fitness and physical activity in elementary school students	BMC Public Health	114
=14	Wong, P.	2008	Effects of a 12-week exercise training programme on aerobic fitness, body composition, blood lipids and C-reactive protein in adolescents with obesity	Annals Academy of Medicine Singapore	114
16	Espana-Romero, V.	2010	Assessing Health-Related Fitness Tests in the School Setting: Reliability, Feasibility and Safety; The ALPHA Study	International Journal of Sports Medicine	110
17	Ramirez-Velez, R.	2015	Reliability of Health-Related Physical Fitness Tests among Colombian Children and Adolescents: The FUPRECOL Study	PLOS ONE	104
18	Chen, Y.	2015	A national school-based health lifestyles interventions among Chinese children and adolescents against obesity: rationale, design and methodology of a randomized controlled trial in China	BMC Public Health	98

(*Continued*)

Table 1 (Continued).

Rank	Authors	Year	Title	Journal	Total Citations
19	Treviño, R.P.	2004	Impact of the Bienestar school-based diabetes mellitus prevention program on fasting capillary glucose levels - A randomized controlled trial	Archives of Pediatrics & Adolescent Medicine	97
20	Kubesch, S.	2009	A 30-Minute Physical Education Program Improves Students' Executive Attention	Mind Brain and Education	95
21	Fisher, A.	2011	Effects of a physical education intervention on cognitive function in young children: randomized controlled pilot study	Bmc Pediatrics	94
22	Cvetkovic, N.	2018	Exercise training in overweight and obese children: Recreational football and high-intensity interval training provide similar benefits to physical fitness	Scandinavian Journal of Medicine & Science in Sports	90
23	Meyer, U.	2014	Long-Term Effect of a School-Based Physical Activity Program (KISS) on Fitness and Adiposity in Children: A Cluster-Randomized Controlled Trial	PLOS ONE	88
24	Eather, N.	2016	Improving health- related fitness in adolescents: the CrossFit Teens™ randomised controlled trial	Journal of Sports Sciences	87
25	Singh, A.S.	2006	Design of the Dutch Obesity Intervention in Teenagers (NRG-DOiT): systematic development, implementation and evaluation of a school-based intervention aimed at the prevention of excessive weight gain in adolescents	Bmc Public Health	84
26	Lakes, K. D.	2013	The Healthy for Life Taekwondo pilot study: A preliminary evaluation of effects on executive function and BMI, feasibility, and acceptability	Mental Health and Physical Activity	81
27	Verstraete, S. J.M.	2007	A comprehensive physical activity promotion programme at elementary school: the effects on physical activity physical fitness and psychosocial correlates of physical activity	Public Health Nutrition	78
28	Bendiksen, M.	2014	Heart rate response and fitness effects of various types of physical education for 8- to 9-year-old schoolchildren	European Journal of Sport Science	76
29	Singh, A.	2007	Short-term effects of school-based weight gain prevention among adolescents	Archives of Pediatrics & Adolescent Medicine	75
30	Baquet, G.	2001	High-intensity aerobic training during a 10 week one-hour physical education cycle: Effects on physical fitness of adolescents aged 11 to 16	International Journal of Sports Medicine	74
=31	Eather, N.	2013	Improving the fitness and physical activity levels of primary school children: Results of the Fit-4-Fun group randomized controlled trial	Preventive Medicine	73
=31	Peralta, L. R.	2009	Promoting healthy lifestyles among adolescent boys: The Fitness Improvement and Lifestyle Awareness Program RCT	Preventive Medicine	73
=33	Resaland, G. K.	2015	Active Smarter Kids (ASK): Rationale and design of a cluster-randomized controlled trial investigating the effects of daily physical activity on children's academic performance and risk factors for non-communicable diseases	BMC Public Health	70
=33	Ewart, C.K.	1998	Effects of school-based aerobic exercise on blood pressure in adolescent girls at risk for hypertension	American Journal of Public Health	70
=35	Larsen, M. N.	2018	Positive effects on bone mineralisation and muscular fitness after 10 months of intense school-based physical training for children aged 8–10 years: the FIT FIRST randomised controlled trial	British Journal of Sports Medicine	68

(*Continued*)

Table 1 (Continued).

Rank	Authors	Year	Title	Journal	Total Citations
=35	Thivel, D.	2011	Effect of a 6-month school-based physical activity program on body composition and physical fitness in lean and obese schoolchildren	European Journal of Pediatrics	68
37	Annesi, J.J.	2005	Effects of a 12-week physical activity protocol delivered by YMCA after-school counselors (youth fit for life) on fitness and self-efficacy changes in 5–12-year-old boys and girls	Research Quarterly for Exercise and Sport	67
=38	Sollerhed, A. C.	2008	Physical benefits of expanded physical education in primary school: findings from a 3-year intervention study in Sweden	Scandinavian Journal of Medicine & Science in Sports	66
=38	Rowland, T.W.	1995	Aerobic response to endurance exercise training in children	Pediatrics	66
=40	Tarp, J.	2016	Effectiveness of a School-Based Physical Activity Intervention on Cognitive Performance in Danish Adolescents: LCoMotion-Learning, Cognition and Motion - A Cluster Randomized Controlled Trial	PLOS ONE	65
=40	Casajus, J. A.	2007	Physical performance and school physical education in overweight Spanish children	Annals of Nutrition and Metabolism	65
42	Brusseau, T. A.	2016	The Effect of a Comprehensive School Physical Activity Program on Physical Activity and Health-Related Fitness in Children From Low-Income Families	Journal of Physical Activity & Health	64
43	Faigenbaum, A. D.	2015	Benefits of strength and skill-based training during primary school physical education	Journal of Strength and Conditioning Research	62
=44	Wassenaar, T. M.	2021	The effect of a one-year vigorous physical activity intervention on fitness, cognitive performance and mental health in young adolescents: the Fit to Study cluster randomised controlled trial	International Journal of Behavioral Nutrition and Physical Activity	59
=44	Seabra, A.	2016	Effects of 6-month soccer and traditional physical activity programmes on body composition, cardiometabolic risk factors, inflammatory, oxidative stress markers and cardiorespiratory fitness in obese boys	Journal of Sports Sciences	59
46	Kim, H-B.	2011	Taekwondo training and fitness in female adolescents	Journal of Sports Sciences	56
=47	Bugge, A.	2012	Effects of a Three-Year Intervention: The Copenhagen School Child Intervention Study	Medicine and Science in Sports and Exercise	54
=47	Zapata, L. B.	2008	Dietary and physical activity behaviors of middle school youth: The youth physical activity and nutrition survey	Journal of School Health	54
=49	Martinez-Vizcaino, V.	2014	Gender differences on effectiveness of a school-based physical activity intervention for reducing cardiometabolic risk: a cluster randomized trial	International Journal of Behavioral Nutrition and Physical Activity	52
=49	Baptista, F.	2012	The role of lean body mass and physical activity in bone health in children	Journal of Bone and Mineral Metabolism	52

Publications by Journal

This research topic may be published in journals from a variety of areas (eg, Sport Science, Public Environmental Occupational Health, Nutrition Dietetics, and Pediatrics) since it is interdisciplinary in nature. Out of the 32 journals, 75.0% published only one article on the investigated topic. The "BMJ-BRITISH MEDICAL JOURNAL" produced the most cited article in 2010 (372 total citations), which evaluated the effects of a school-based physical activity programme (KISS) on fitness and adiposity in primary schoolchildren. As can be seen in Table 2, we analyzed eight journals, each of which had two or more publications. These journals published 26 papers, accounting for 52.0% of the sample articles. At

Table 2 Summary of Productivity of the Most Active Journals

Rank	Journal[a]	Papers	Number of citations	CPP	JIF2024	JCI2024
1	BMC Public Health	5	481	96.2	3.6	1.18
=2	Journal of Sports Sciences	4	346	86.5	2.5	0.97
=2	PLOS ONE	4	582	145.5	2.6	0.85
=3	Archives OF Pediatrics Adolescent Medicine	3	388	129.33	5.731*	NA
=3	International Journal of Behavioral Nutrition and Physical Activity	3	435	145	5.5	1.5
=3	Scandinavian Journal of Medicine Science in Sports	3	331	110.33	3.8	1.41
=7	International Journal of Sports Medicine	2	184	92	2.2	0.72
=7	Preventive Medicine	2	146	73	3.2	1.17

Notes: [a]Journals with at least two articles were summarized; * Archives of Pediatrics Adolescent Medicine only has JIF in 2014.
Abbreviation: NA, Not available.

the top of the list is the "BMC PUBLIC HEALTH". This journal has been active in recent years and has four papers published (481 total citations, CPP = 96.2), representing 10.0% of the entire sample. Meanwhile, "PLOS ONE" has the highest number of citations (582 total citations, CPP = 145.5).

To further contextualize journal influence, we incorporated the 2024 Journal Impact Factor (JIF) and Journal Citation Indicator (JCI) values from the active journals (Table 2). BMC Public Health, the most productive journal in this dataset, had a JIF of 3.6 and a JCI of 1.18, indicating above-average citation performance. PLOS ONE (JIF 2.6, JCI 0.85) and the Journal of Sports Sciences (JIF 2.5, JCI 0.97) also demonstrated substantial visibility. Notably, the International Journal of Behavioral Nutrition and Physical Activity exhibited both high productivity and impact, with a JIF of 5.5 and a JCI of 1.5, making it the highest-impact outlet among the journals with multiple publications. These metrics help illustrate the scientific influence and dissemination potential of the journals contributing to the top-cited literature in this field.

Publications by Countries/Regions

The articles contained are distributed across over 24 different countries. At the present time, the scope of this study issue is not worldwide because no authors from African nations/institutions have produced academic works in the field of research. Table 3 lists the most active countries (n > 2). The majority of contributing countries were high-income regions with advanced academic and research systems, which may partially explain their higher publication and citation influence in this field. More than 60% (n = 31) of all publications came from the top three countries, with the United States contributing the most (19

Table 3 Summary of Productivity of the Most Active Countries

Rank	Country[a]	Papers	Number of citations	CPP
1	USA	19	1906	100.3
=2	Australia	6	972	162
=2	Spain	6	628	104.7
4	Denmark	5	390	78
=5	England	4	297	74.3
=5	Netherlands	4	617	154.3
=5	Norway	4	265	66.3
=5	Sweden	4	405	101.3
=5	Switzerland	4	808	202
=10	Germany	3	553	184.3
=10	Portugal	3	187	62.3

Notes: [a]Counties with at least two articles were summarized.

publications, 1906 total citations, CPP = 100.3) and accounting for 38.0% of all included articles. Australia (6 publications, 972 total citations, CPP=162.0) and Spain (6 publications, 628 total citations, CPP=104.7) were tied for second.

Analysis of Authors

Figure 1 shows the network visualization map for co-authorship. The co-authorship analysis of the 26 most highly cited papers in the field of PE for PF reveals five clusters of authors. Zahner, I., Kriemler, S., and Puder, J.J. led the most dominant cluster of authors (see in red), and also collaborate with the other dominant cluster of authors in the field (see in green).

Analysis of Keyword Co-Occurrence

Analysis of keyword co-occurrence allows for the clustering of terms according to their degree of relatedness in Figure 2. The frequency of occurrence is shown by the size of the cycles. Links between items that we consider to be particularly significant are indicated by thicker lines. As shown in Figure 3, the most frequent words include "children" and "adolescents", reflecting the population studied; "exercise", "physical", "fitness", and "strength", indicating health-related fitness; "interventions" and "programs", representing the research type and design.

Two research focuses emerged from the abovementioned terms. The leading research hotspot refers to physical education didactics. The most practical format for delivering physical education for school-aged children and adolescents is lessons and curriculum. Despite the traditional physical education didactics (eg, aerobic and core conditioning training), recent studies began to incorporate games, such as video games[33] and modified ball games,[34,35] which make the physical education more enjoyable. These game-based interventions were developed based on some innovative pedagogical instructional models, such as Teaching Games for Understanding (TGfU).[34,35] Moreover, indoor/home exercises as physical education approaches were also studied.[36,37]

The second research hotpot concentrates on the health-related fitness of students, including aerobic capacity/fitness, (muscular)strength, muscular endurance, flexibility, and body composition. This implies that most current physical education programs target health-related fitness as the primary outcome. Nevertheless, recent studies have addressed the psychological benefits of physical education programs, such as improving psychological health, cognitive functioning, and academic performance.[38,39]

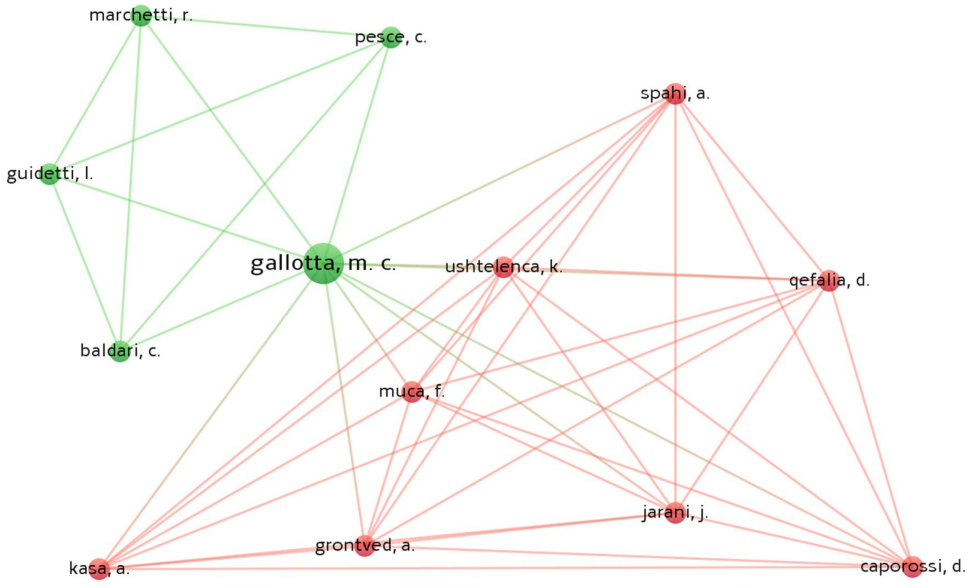

Figure 2 Authors Cooperation Network Mapping.

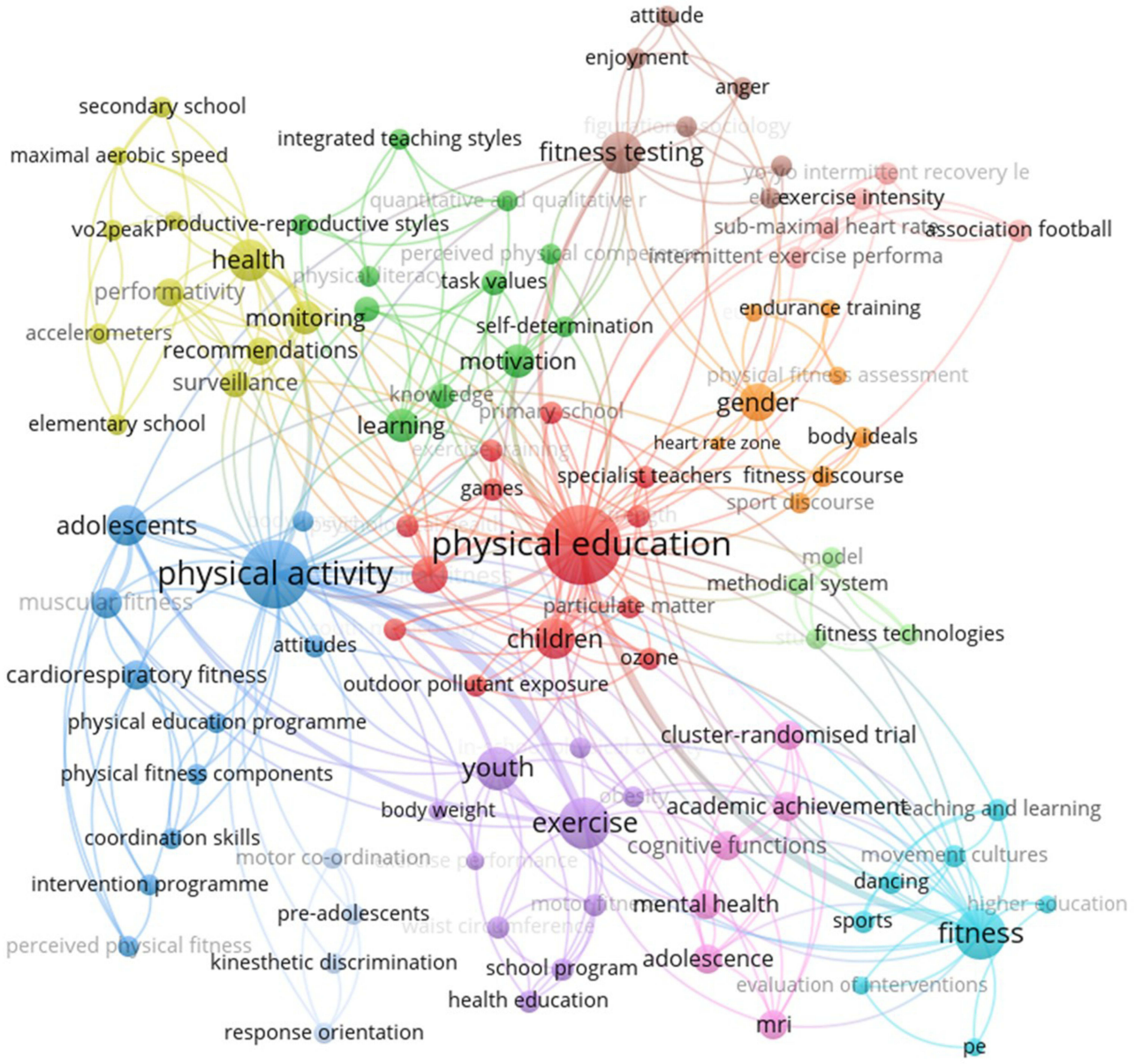

Figure 3 Keyword co-occurrence analysis.

Discussion

We analyzed and presented bibliometric findings of the 50 most cited publications on physical education and physical fitness among children and adolescents in this study. This citation analysis provides quantitative information about authors, journals, countries, and institutions by identifying highly cited studies on publications on physical education and physical fitness among children and adolescents.[40] The most cited papers on physical education and physical fitness among children and adolescents were cited between 0 to 617 times. In many fields most cited papers received more citations than the current study. These include broad research topics such as hypertension (range = 582–7248;[41]) and diabetes (range = 964–17,779;[42]), intermediate research topics such as physical activity (range = 297–8068;[43]), and specific research fields such as the research on football (range = 251–869;[44]) and clinical orthopedic sports medicine (range = 229–1629;).[45] The field of physical fitness is comparatively broader in scope, but we narrowed its scope to studies combining physical education with physical fitness in a specific population (ie, children and adolescents).

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Therefore, the findings of the study may not be surprising. Moreover, the citation pattern is dependent on several factors and tends to vary across different fields. These factors include field-specific factors such as the scope of the field, prevailing publishing model in the field, number of researchers in a field, geographic origin, and primary language of researchers in the field or citation analysis-specific factors, such as the number of papers considered as top cited in the field.[40,46,47]

Only 3 of the most cited 50 papers on physical education and physical fitness among children and adolescents were published before 2000. With only one exception, papers published after 2000 received more citations than the older ones. The paper "The effects of a 2-year physical education program (SPARK) on physical activity and fitness in elementary school students" also occupied first place in the list of the most cited papers on physical education and physical fitness among children and adolescents. The reason why older publications may lose recognition may be attributed to the availability of more recent citable alternative papers as a result of advancement in the field or replacement of old theoretical frameworks by a new one.[47] It has also been argued that older papers do not receive more citations because of cross-citation or inappropriate citation practices where authors omit citing the original source.[43]

Most of the most cited publications on physical education and physical fitness among children and adolescents were published by authors from institutions in high-income countries, with very few published by authors from low- and middle-income countries (eg, China, Ukraine). These findings are similar to the citation analyses of most cited papers in many health fields.[40,43,48] The dominance of high-income countries in the top-cited literature reflects broader structural inequities in global research production, including disparities in funding availability, research infrastructure, and access to publication networks. Such imbalances may limit the representation of diverse cultural, educational, and policy contexts in youth physical fitness research, thereby narrowing the generalizability of current evidence. Strengthening research equity requires greater investment in capacity-building for low- and middle-income countries, including support for local data systems, researcher training, and equitable access to publication platforms. At the same time, the observed concentration of expertise in high-income regions highlights opportunities for international collaboration. Joint research initiatives, shared datasets, and cross-country comparative studies could foster a more globally representative evidence base and help integrate underrepresented regions into the scientific landscape. Such efforts would enhance methodological diversity and promote a more inclusive understanding of physical fitness development across different socioeconomic and cultural settings.[43,48] Moreover, it has been suggested that authors from high-income countries tend to work with authors from a country of the same income group as well as cite papers of such authors.[43,47]

The most cited papers on physical education and physical fitness among children and adolescents were published in specific journals. The most prolific journal was the International Journal of Environmental Research and Public Health (n = 5; CPP = 6.0), whereas the *Journal of School Health* (n = 2) had the most citations per paper (CPP = 33). The list included journals specific to physical education, movement behaviour, psychology, public health and pediatrics, or youth. It may be due to the nature of the study that the papers were published in specific journals, unlike other bibliometrics studies, which were broader in focus.[49]

The top 50 most-cited papers on physical education and physical fitness among children and adolescents covered a broad range of topics, as shown through the keyword co-occurrence analysis. These included strength, cardiorespiratory and musculoskeletal fitness, cardiovascular and metabolic health, cognitive and psychological outcomes, school-based interventions, behavioral patterns, risk factors, learning processes, attitudes, and emerging themes such as gamification. While these clusters demonstrate the thematic diversity of landmark studies, they also reveal several important research gaps. First, most highly cited papers rely on cross-sectional designs, limiting insights into developmental trajectories and causal mechanisms linking physical fitness to long-term health outcomes. Second, evidence is heavily concentrated in high-income countries, leaving contextual determinants of youth fitness in low- and middle-income settings underrepresented. Third, considerable heterogeneity in fitness assessment protocols restricts comparability across studies and underscores the need for standardized measurement frameworks. Finally, although emerging areas such as gamification and cognitive benefits appear in the network, these domains remain theoretically fragmented and insufficiently integrated into comprehensive models of youth fitness development. Notably, major noncommunicable disease outcomes (eg, diabetes, cancer) commonly studied in adults

are understandably absent in this citation landscape, suggesting opportunities for earlier life-course research. Addressing these gaps will be essential for advancing a more cohesive and globally representative evidence base.

This is the first citation analysis of the 50 most cited publications on physical education and physical fitness among children and adolescents. However, this study has some limitations. Indeed, studies show that there is a likelihood of inaccuracies in bibliometric parameters included in Web of Science Core Collection.[43] While the use of WoSCC has its advantage of citation tracking back to papers published in 1950, it has the tendency to miss some papers that would appear in other databases, such as the Scopus database. Thus, the number of most cited papers in the WoSCC may differ from databases like the Scopus database, which limits the generalizability of the list of the 50 most cited publications on physical education and physical fitness among children and adolescents to other scientific databases. Moreover, the use of WoSCC only leads to the omission of publications from some regions and in other languages, which necessitates future advances in bibliometric software to address the issue of merging databases. Lastly, the findings of this citation analysis may have been affected by the search strategy used for finding the most cited papers on physical education and physical fitness among children and adolescents.

Conclusion

The most cited studies on physical education and physical fitness among children and adolescents span diverse themes, but their influence is concentrated in high-income countries, especially the United States and parts of Europe. This pattern highlights the need for broader evidence from underrepresented regions. For researchers, the findings point to priorities such as standardizing fitness assessments, conducting longitudinal studies, and expanding cross-cultural research. For policymakers, the evidence reinforces the importance of investing in youth fitness monitoring systems and strengthening school-based activity programs to support equitable and data-informed health strategies.

Institutional Review Board Statement

Not applicable, due to this study not involving humans or animals.

Informed Consent Statement

Not applicable, due to this study not involving humans or animals.

Author Contributions

Conceptualization, X.W. and K.X.; methodology, Z.X.; software, X.Y. and J.Y.; validation, X.W. and X.Y.; formal analysis, K.Z. and J.Y.; investigation, K.Z.; resources, X.W; data curation, K.Z.; writing—original draft preparation, X.Y.; writing—review and editing, X.W., J.Y., and X.Y.; visualization, K.Z. and Z.X.; supervision, K.Z.; project administration, J.Y. All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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