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ARTIFICIAL INTELLIGENCE IN PHYSICAL EDUCATION: A BIBLIOMETRIC AND SYSTEMATIC REVIEW

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Abstract

Background. The rapid development of artificial intelligence (AI) has significantly influenced various educational domains, including physical education. However, research on AI in physical education remains fragmented, and a comprehensive mapping of research trends, thematic structures, and future directions is still limited.
Aim. This study aims to examine publication trends, intellectual structures, and the theoretical and practical implications of artificial intelligence research in physical education.
Material and methods. A systematic literature review combined with bibliometric analysis was conducted in this study. The article selection process followed the PRISMA framework,

and data were retrieved from the Scopus database for the period 2016-2025. A total of 170 articles that met the inclusion criteria were analyzed using VOSviewer to identify publication trends, leading journal sources, author productivity, and keyword co-occurrence networks.

Results. The results indicate substantial growth in research output in recent years, demonstrating that artificial intelligence in physical education is a rapidly expanding, multidisciplinary research field. Dominant research themes include machine learning, deep learning, big data, virtual reality, and wearable technology, which are closely associated with teaching quality, learner motivation, and performance outcomes.

Conclusions. In conclusion, artificial intelligence represents a significant and sustainable research direction in physical education, offering substantial potential to advance pedagogical innovation and evidence-based practice in future educational settings.

Keywords: Artificial Intelligence, Physical Education, Bibliometrics

Introduction

The rapid advancement of digital technologies, particularly artificial intelligence (AI), has brought about significant transformations across various sectors, including education. Artificial intelligence enables intelligent data analysis, machine learning, adaptive decision-making, and personalized services based on user needs. Within the context of 21st-century education, AI is increasingly regarded as a strategic technology with the potential to enhance learning quality, improve teaching effectiveness, and increase the overall efficiency of educational systems (Akhiruyanto & Yudhistira, 2024). Despite the growing adoption of AI in general education and digital learning environments, its integration into physical education remains limited and challenging.

Physical education possesses distinctive characteristics that emphasize physical activity, direct interaction, and the simultaneous development of psychomotor, affective, and cognitive domains (Ginanjar et al., 2021). These characteristics make integrating AI-based technologies more complex than in theoretical subjects, resulting in continued reliance on conventional instructional approaches and underutilization of intelligent systems (Zhang & Fu, 2022). Existing studies suggest that AI can be applied in physical education through technologies such as machine learning, deep learning, big data analytics, virtual reality, and wearable devices to support movement analysis, physical activity monitoring, performance assessment, and real-time feedback (Z. Li & Wang, 2021; Xu et al., 2022; Saido et al., 2024; Hsia et al., 2024; Song, 2024; Hajder et al., 2025). Nevertheless, significant conceptual and practical challenges persist in effectively integrating AI into physical education learning processes. These challenges include limited teacher knowledge of AI technologies, insufficient school infrastructure, misalignment between AI applications and physical education curricula, and ethical and data privacy concerns related to students.

Furthermore, scholarly research on artificial intelligence in physical education remains fragmented. Many studies focus on specific technological applications without adequately linking them to physical education pedagogy or examining their long-term impacts on learning quality and student development (Moore et al., 2023; Miao et al., 2025; Wu et al., 2025).

Consequently, a comprehensive understanding of dominant research themes, interrelationships among topics, key contributors, and future research directions has yet to be established. Another critical issue is the lack of studies that systematically analyze publication trends, journal distribution, and the intellectual structure of AI research in physical education (AL-Sinani & Al Taher, 2023). Without comprehensive mapping, researchers risk duplicating existing studies, overlooking significant research gaps, and struggling to establish strong research novelty (Aluintany et al., 2025). This limitation also hinders practitioners and policymakers from making evidence-based decisions grounded in a holistic understanding of the field.

In response to these challenges, an integrated research approach combining a systematic literature review (SLR) with bibliometric analysis is necessary to comprehensively map the development of artificial intelligence research in physical education. This approach enables the identification of research trends, core themes, keyword relationships, and the contributions of authors and journals through objective, data-driven methods (Rahman et al., 2024). Supported by tools such as VOSviewer, bibliometric mapping offers clear visualizations of the structure and dynamics of the research landscape. Therefore, this study aims to provide a comprehensive overview of artificial intelligence research in physical education based on Scopus-indexed publications from 2016 to 2025.

The findings are expected to address gaps in previous studies, contribute to the theoretical development of conceptual frameworks, and offer practical implications for educators, researchers, and policymakers in implementing artificial intelligence in physical education effectively, ethically, and sustainably.

Methods
Study design Procedure
A systematic literature review combined with a bibliometric approach was employed to quantitatively analyze scholarly publications and identify research trends, patterns, and key contributors within the field. The use of a structured framework such as PRISMA ensures a systematic, transparent, and replicable process for literature identification and selection, thereby providing a comprehensive overview of the research topic (Page et al., 2021).

This study employed a quantitative bibliometric approach to analyze scientific publications related to artificial intelligence in physical education published between 2016 and 2025. Bibliometric analysis was the primary analytical technique used to examine research productivity, publication trends, collaboration patterns, and the field's intellectual structure. This research is categorized as a theoretical study aimed at analyzing the development of publication output over time and identifying its current research direction (Hernández-Beltrán et al., 2024). The bibliometric approach enables the identification of essential indicators in scientific production, including leading institutions, productive authors, contributing countries, frequently used keywords, and citation patterns (Becerra-Patiño et al., 2025). Through quantitative mapping complemented by qualitative interpretation, this method provides a comprehensive understanding of the evolution and dynamics of the research domain.

Search Strategy
The data search was conducted in December 2025 using the Scopus database, which is multidisciplinary and indexes peer-reviewed international journals (Salinas-Ríos & García López, 2022). The literature review followed PRISMA recommendations (Haddaway et al., 2022) and used the advanced search feature across the title, abstract, and keyword fields. The primary search query used was: TITLE-ABS-KEY ("artificial intelligence") AND TITLE-ABS-KEY ("physical education") AND PUBYEAR > 2015 AND PUBYEAR < 2026. Additional related keywords were examined to ensure comprehensive coverage and relevance of the retrieved documents (Plakias, 2025). The document selection process was conducted

systematically through the stages of identification, screening, eligibility, and inclusion in accordance with PRISMA guidelines.

Selection criteria

The inclusion criteria applied in this study were: (1) original research articles, (2) publications written in English, (3) articles indexed in Scopus, (4) studies published between 2016 and 2025, and (5) research specifically focusing on artificial intelligence within the context of physical education. Included studies were required to directly address the implementation, development, evaluation, or application of artificial intelligence technologies in physical education settings.

Articles were excluded if they were book series, books, conference proceedings, non-English publications, articles published outside the specified time frame, articles without accessible full text, or studies that only marginally mentioned artificial intelligence or physical education without substantive discussion. The application of these criteria ensured the relevance, consistency, and quality of the analyzed dataset.

Study Selection Process

The initial search identified 415 records. After removing 45 duplicate articles, 370 records remained for screening. During screening, documents were excluded based on document type, including book series (n = 41), books (n = 12), and conference proceedings (n = 89), resulting in 273 journal articles. In the eligibility stage, further exclusions were applied to non-English publications, including Russian (n = 13), Portuguese (n = 3), Korean (n = 2), and Spanish (n = 2), as well as articles published outside the 2016–2025 time frame (n = 6). Additionally, 76 articles were excluded due to the unavailability of the full text. After completing all stages of the selection process, 170 articles met the inclusion criteria and were included in the final bibliometric analysis.
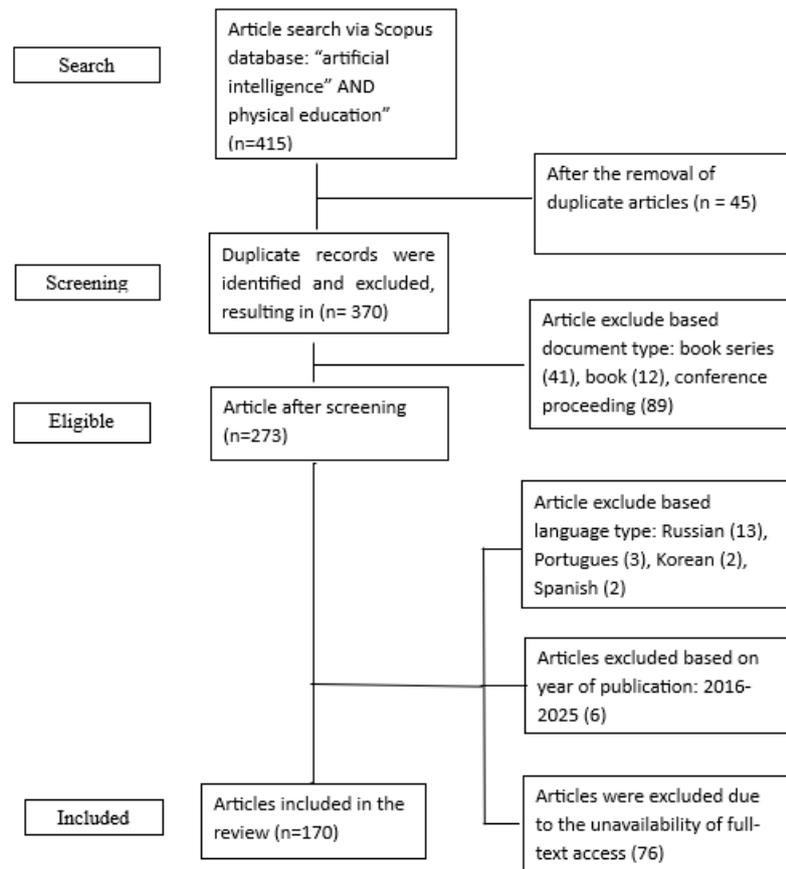
Figure 1. Systematic Literature Review: Information flow using PRISMA

Biblometric analysis

The bibliometric analysis was conducted using VOSviewer to perform network visualization and mapping of the selected publications. The analysis focused on collaboration networks among countries and authors, as well as on keyword co-occurrence and citation structures, to identify the intellectual structure and thematic development of research on artificial intelligence in physical education.

To ensure data validity and consistency, a thesaurus file was applied during preprocessing to standardize variations in journal titles, author names, and keywords, such as unifying "AI" and "artificial intelligence" and harmonizing variations in author initials. At each analytical stage, several parameters were defined, including the minimum threshold for inclusion in network mapping, the criteria for determining node size based on the number of documents, citations, or keyword occurrences, and the type of visualization used (network or overlay). The application of minimum thresholds was aimed at maintaining network clarity and highlighting the most influential elements within the research domain (Kara, 2025). In the resulting visualization maps, each node represents a country, author, or keyword; node size reflects frequency or influence; connecting lines indicate collaborative relationships; line thickness represents the strength or intensity of collaboration (van Eck & Waltman, 2010); and different colors signify distinct thematic clusters (Esmaeili Mahyari et al., 2025).

Result And Discussion

The findings of this study are based on an analysis of 170 articles retrieved from the Scopus database using the keywords "artificial intelligence" AND "physical education." The analysis

draws on publication data, including the number of articles, annual publication trends, and journal sources. In addition, this study identifies the most influential components in the field of artificial intelligence in physical education, encompassing key authors, institutional affiliations, and contributing countries. RQ1: Does the investigation of artificial intelligence in physical education remain a significant topic for future scholarly research?

The publication trend illustrated in the figure shows an apparent, sustained increase in scholarly output on artificial intelligence in physical education over the period 2016–2025. During the early years (2016–2019), the number of publications remained relatively low, indicating that the topic was still in an exploratory phase. However, starting in 2020 (Yang et al., 2020; Deng et al., 2020; Mokmin, 2020; Hu, 2020; Priymak et al., 2020), a noticeable growth trajectory emerged, followed by a sharp increase between 2021 and 2022, reflecting heightened academic interest and research activity. Although a temporary decline is observed in 2023, the number of publications rises again substantially in 2024 and reaches its highest level in 2025. This upward trend in recent years suggests that research on artificial intelligence in physical education is not only ongoing but also gaining momentum. Overall, these findings indicate that the investigation of artificial intelligence in physical education remains a significant and relevant topic for future scholarly research.
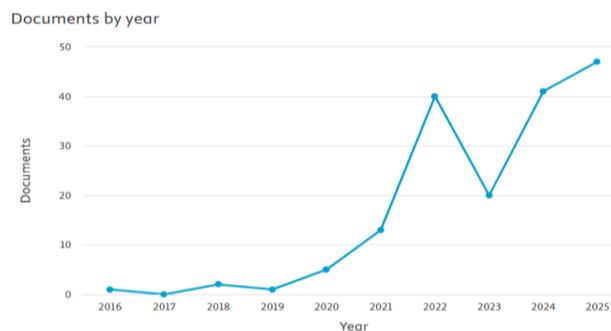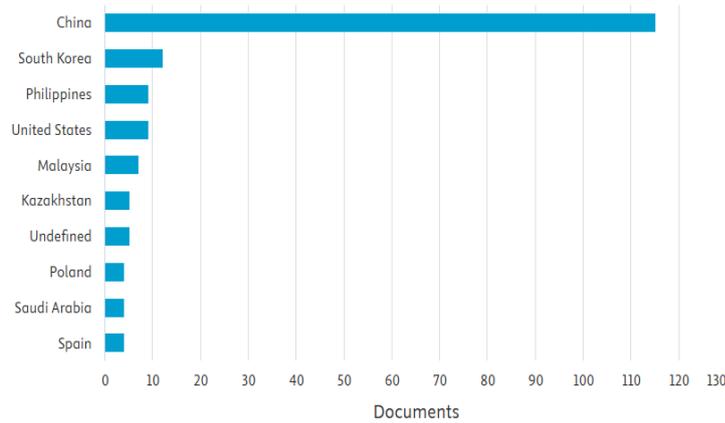

Source: Scopus database
Figure 2. Number of artificial intelligence physical education publications

The consistent growth pattern highlights the field's expanding importance, driven by technological advancements and the increasing integration of artificial intelligence in educational and physical activity contexts. Consequently, this area presents strong potential for continued theoretical development and practical innovation in future studies.

RQ2: How is current research on artificial intelligence in physical education distributed?

The figure illustrates the geographical distribution of research on artificial intelligence in physical education, revealing a highly uneven pattern across countries. China emerges as the dominant contributor, accounting for the most publications by a substantial margin. This dominance indicates that China currently serves as a central hub for research and development in artificial intelligence applications in the physical education domain, likely supported by strong research policies, robust technological infrastructure, and significant academic investment. Beyond China, research contributions are distributed among several countries, including South Korea, the Philippines, the United States, Malaysia, Kazakhstan, Poland, Saudi Arabia, and Spain, each contributing a comparatively smaller number of publications. Although the volume of research from these countries is more limited, their presence demonstrates that scholarly interest in artificial intelligence in physical education is global in scope, spanning multiple regions such as Asia, North America, and Europe.

Figure 3. Number of articles by country of territory (top 10 countries)

The pronounced disparity in publication output suggests that current research activity remains concentrated in a small number of countries, while many regions are underrepresented. This distribution highlights significant opportunities for broader international collaboration and for expanding research efforts in countries with emerging interest in artificial intelligence–based physical education.

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Figure 4. Network country visualization

The visualization clearly shows China as the most central and influential actor in the global research network, indicated by the largest node and the highest number of collaborative links. China maintains extensive research collaborations with countries across multiple regions, including South Korea, the United States, Poland, the Philippines, Malaysia, Indonesia, India,

Turkey, Spain, Saudi Arabia, and Pakistan. This central positioning highlights China's pivotal role in shaping and coordinating international research efforts in this field.

Several regional collaboration clusters are also evident, particularly within Southeast and Central Asia, involving countries such as Indonesia, Malaysia, the Philippines, Kazakhstan, and Uzbekistan. Although these countries exhibit growing collaborative ties, their overall contributions and network centrality remain lower than those of China. In contrast, countries such as the United States and Poland appear more peripheral, indicating relatively limited collaborative engagement within the network. Overall, the collaboration map suggests that research on artificial intelligence in physical education is characterized by a highly centralized collaboration structure, dominated by a single leading country. Nevertheless, the emergence of regional clusters indicates increasing opportunities for broader international collaboration and the diversification of research partnerships in future studies.
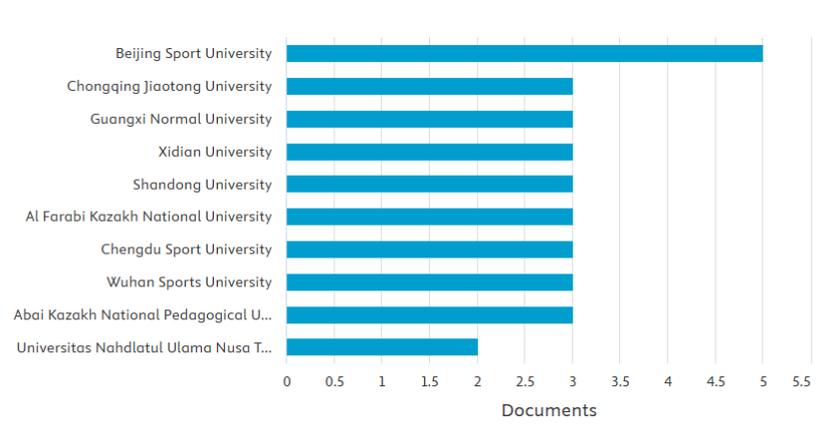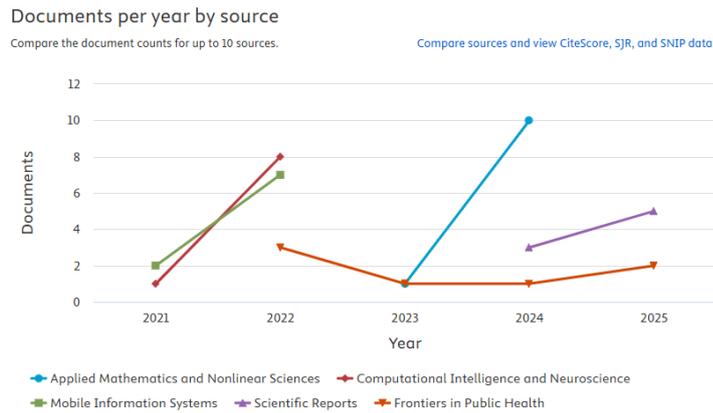

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Figure 5. Number of articles by affiliations

The figure illustrates the institutional distribution of publications on research in artificial intelligence in physical education. The results indicate that research output in this field is dominated by higher education institutions from China, particularly those with a strong focus on sport science and technology. Beijing Sport University emerges as the most productive institution, contributing the highest number of publications. This finding underscores the university's leading role in advancing research at the intersection of artificial intelligence and physical education. Other prominent contributors include Chongqing Jiaotong University, Guangxi Normal University, Xidian University, Shandong University, Chengdu Sport University, and Wuhan Sports University, each demonstrating consistent research productivity.

In addition to Chinese institutions, the figure highlights contributions from institutions outside China, such as Al-Farabi Kazakh National University and Abai Kazakh National Pedagogical University, indicating the growing involvement of Central Asian institutions in this research domain. Furthermore, the presence of Universitas Nahdlatul Ulama Nusa Tenggara reflects emerging research engagement from Southeast Asia, although with comparatively lower publication output.
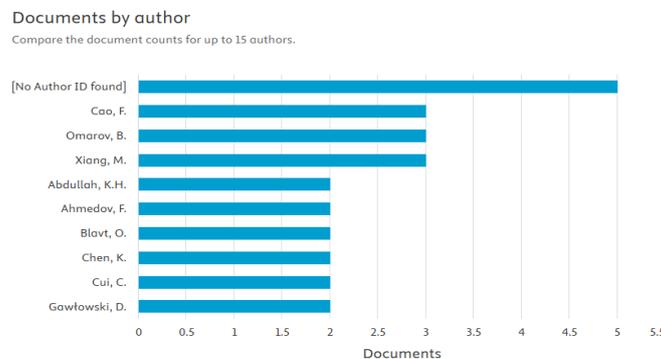
Source: Scopus database
Figure 6. Number of articles by sources (top 10 sources)

The figure illustrates the annual distribution of publications by journal source from 2021 to 2025 within the field of artificial intelligence in physical education. The visualization reveals distinct publication patterns across journals, indicating varying levels of engagement and thematic emphasis over time. Applied Mathematics and Nonlinear Sciences demonstrates a pronounced increase in publications in 2024, recording the highest output among the listed sources. This trend suggests a growing scholarly interest in mathematical and computational approaches to artificial intelligence applications in physical education.

In contrast, Computational Intelligence and Neuroscience exhibits a notable surge in 2022, reflecting an intensified focus on computational intelligence and neuroinformatics perspectives within educational and physical activity research. Mobile Information Systems shows a relatively stable contribution during the early years of the observed period, particularly in 2021 and 2022, highlighting the relevance of mobile technologies and information systems in supporting artificial intelligence–driven physical education. Meanwhile, Scientific Reports shows an upward trend from 2024 to 2025, indicating an expansion of multidisciplinary research and increased recognition of this topic in high-impact, broad-scope journals.

Additionally, Frontiers in Public Health publishes a more moderate yet consistent number of papers across the study period, underscoring the intersection of artificial intelligence, physical education, and public health outcomes. Overall, the distribution of publications by journal source underscores the multidisciplinary nature of research on artificial intelligence in physical education.

Source: Scopus database
Figure 7. Count of publications by author (top 10 authors)

The figure presents the distribution of publications by author in the field of artificial intelligence in physical education, highlighting the most productive contributors within the analyzed dataset. The results indicate a concentration of research output among a limited number of authors, suggesting the presence of key contributors who play a central role in advancing this research domain.

The "No Author ID found" category records the most documents, reflecting limitations in author identification within the Scopus database, such as incomplete metadata or inconsistencies in author profiling. This issue is common in bibliometric analyses and underscores the importance of standardized author identifiers for accurate attribution and collaboration mapping. Among the identified authors are Cao et al. (2022), Omarov et al. (2023), and Xiang (2022). emerge as the most prolific contributors, each producing three documents. Their publication frequency indicates sustained scholarly engagement and positions them as influential authors within this research area. Several other authors, including (Kardiyanto et al., 2024; Ridwan et al., 2025; Blavt et al., 2025; Chen et al., 2025; Li et al., 2024; Makaruk et al., 2025).

Overall, this authorship distribution suggests that research on artificial intelligence in physical education is driven by a core group of recurring contributors, complemented by a broader set of scholars with more limited output. This pattern indicates a developing research field in which expertise is gradually consolidating, while opportunities remain for expanded collaboration and increased author participation in future studies.

RQ3: What theoretical and practical implications can be identified to inform future research directions?

The analysis was conducted on 170 manuscripts retrieved from the Scopus database. VOSviewer was employed as a bibliometric visualization tool to examine metadata and identify patterns with theoretical and practical implications for future research on artificial intelligence in physical education. The results of the metadata analysis generated with VOSviewer enable researchers and practitioners to gain a clearer understanding of prevailing research assumptions, thematic emphases, and empirical findings regarding the application of artificial intelligence in physical education. Furthermore, the bibliometric analysis facilitated by VOSviewer reveals which variables and research themes have been most extensively explored, thereby providing a robust foundation for identifying research gaps and guiding future studies. From a practical perspective, the findings derived from the literature analysis using VOSviewer can support practitioners in effectively implementing artificial intelligence–based approaches within physical education contexts, contributing to evidence-informed instructional design and innovation.
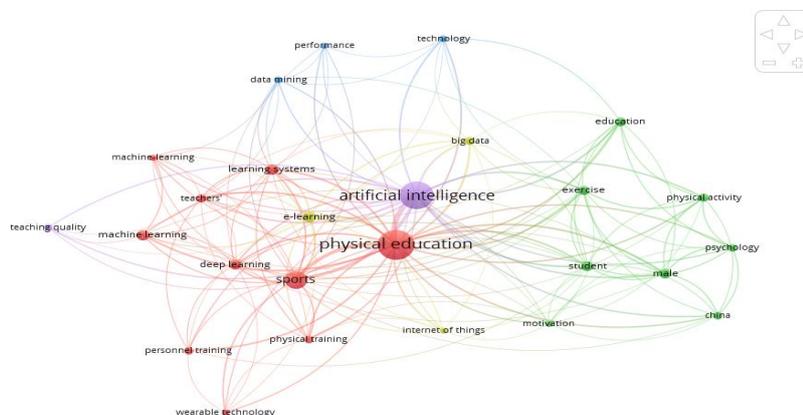
Source: Output VOSviewer software
Figure 8. Co-occurrence framework and representation of key terms

Table 1: keywords by authors

Rank	Keyword	Total link strength
1	Physical education	760
2	Artificial intelligence	655
3	e-learning	116
4	Deep learning	97
5	Big data	69
6	Virtual reality	66
7	Physical training	53
8	Teaching quality	37
9	Motivation	33
10	Performance	30
11	Machine-learning	29
12	Wearable technology	29

Source: Output VOSviewer software

Presents the author's keyword analysis based on total link strength, which reflects the intensity of co-occurrence relationships among keywords within the literature on artificial intelligence in physical education. The results indicate that "Physical Education" (total link strength = 760) and "Artificial Intelligence" (total link strength = 655) are the most dominant keywords, confirming that the core focus of the analyzed studies lies at the intersection of artificial intelligence applications and physical education contexts.

Keywords related to digital learning and advanced computational methods, such as "e-learning" (116), "deep learning" (97), and "machine learning" (29), demonstrate strong associations with the primary themes. This finding highlights the increasing integration of intelligent systems and data-driven approaches in the design and delivery of physical education instruction. Additionally, the presence of "big data" (69) suggests the growing importance of large-scale data analytics in understanding learner behavior, performance assessment, and personalized training.

Emerging technology-oriented keywords, including "virtual reality" (66) and "wearable technology" (29), indicate a trend toward immersive and sensor-based learning environments that support skill acquisition, movement analysis, and real-time feedback in physical education settings. Meanwhile, pedagogical and outcome-related keywords such as "physical training" (53), "teaching quality" (37), "motivation" (33), and "performance" (30) emphasize that technological advancements are closely linked to instructional effectiveness and learner outcomes.

This study provides a comprehensive overview of the research landscape on artificial intelligence (AI) in physical education (PE) by integrating a systematic literature review and a bibliometric analysis. By applying the PRISMA framework, 170 relevant articles published between 2016 and 2025 were rigorously selected from the Scopus database, ensuring methodological transparency and replicability. This integrated approach enables a robust interpretation of publication trends, thematic structures, and intellectual contributions within the field. The publication trend analysis reveals a consistent increase in scholarly output, particularly after 2020, indicating that AI in physical education remains a highly relevant and expanding research topic.

This growth aligns with the accelerated adoption of digital technologies, learning analytics, and intelligent systems in educational contexts. The sustained increase in publications suggests that AI is no longer viewed as an auxiliary tool but as a core component of pedagogical

innovation in physical education, with strong potential for future scholarly exploration (Tseng et al., 2024). The distribution of publications across diverse journal sources highlights the multidisciplinary nature of AI research in physical education. Contributions from journals focusing on computational intelligence, applied mathematics, information systems, education, and public health indicate that this field transcends traditional disciplinary boundaries (Zhong et al., 2025). Such diversity reflects the convergence of technological innovation, pedagogical theory, and health-related outcomes, underscoring the necessity of interdisciplinary approaches to address complex educational challenges.

The bibliometric mapping and keyword co-occurrence analysis reveal that physical education and artificial intelligence function as the central thematic nodes, strongly connected to emerging technologies such as deep learning, machine learning, big data, virtual reality, and wearable technology (Kong & Wang, 2019; J. Zhang & Zhang, 2023; Annaluru et al., 2023; Yilmaz et al., 2025; Shcherbin et al., 2025; Xue et al., 2025). These findings demonstrate a clear shift toward data-driven, technology-enhanced learning environments that emphasize personalized instruction, performance monitoring, and adaptive feedback mechanisms. Notably, the frequent association with pedagogical constructs such as teaching quality, motivation, and performance underscores the growing emphasis on educational impact rather than technological novelty alone (Ajlouni et al., 2023). The analysis of author productivity indicates that a core group of recurring contributors currently shapes the field, while broader participation remains limited. This pattern suggests that research on AI in physical education is still in its developmental stage, with substantial opportunities to expand international collaboration and diversify methods. Strengthening co-authorship networks and cross-institutional partnerships may accelerate theoretical advancement and empirical validation in future studies.

From a theoretical perspective, this study advances understanding of AI integration in physical education by clarifying dominant research themes and identifying underexplored areas, including ethical considerations, teacher readiness, and long-term learning outcomes (Wang et al., 2025). The bibliometric insights provide a foundation for developing conceptual frameworks and evidence-based models that align AI technologies with pedagogical principles. Practically, the findings offer valuable guidance for educators, policymakers, and practitioners. The growing use of AI-driven analytics, immersive technologies, and wearable devices demonstrates strong potential for enhancing instructional quality, learner engagement, and performance assessment in physical education. Consequently, the effective implementation of AI requires not only technological readiness but also pedagogical alignment and institutional support.

Conclusion

This study synthesizes the development of research on artificial intelligence (AI) in physical education (PE) through an integrated systematic literature review and bibliometric analysis. Following the PRISMA framework, 170 peer-reviewed articles published between 2016 and 2025 were systematically selected from the Scopus database, ensuring methodological rigor and transparency. This approach enabled a structured examination of publication trends, thematic patterns, and intellectual contributions within the field. The findings indicate that AI in physical education remains a relevant and growing research domain, with a notable increase in scholarly output in recent years. This trend reflects the expanding role of intelligent technologies in supporting pedagogical innovation, learning analytics, and performance assessment in physical education contexts. AI has evolved from a supplementary technological tool into a core component of contemporary educational practice. This study confirms that artificial intelligence represents a strategic and sustainable research direction in physical education. The systematic and bibliometric synthesis presented herein provides a valuable

reference for future empirical studies, interdisciplinary collaboration, and evidence-based implementation of AI in physical education.

Generative AI Use Statement

Author Contributions

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Conflicts of Interest

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