Interdisciplinary Journal of Virtual Learning in Medical Sciences

Review Article

Meta-Synthesis of Qualitative Research on Artificial Intelligence in Physical Education: Performance, Ethics, and Global Trends

Zainab Gorzinmataee[1*], Fatemehzahra Rezaee[1], Mohammadreza Farrokhnia[2]

[1]*Department of Educational Science, Farhangian University, Tehran, Iran*
[2]*Department of Learning, Data Analytics and Technology, University of Twente, Netherlands*

ABSTRACT

Background: This study explores the transformative potential of Artificial Intelligence (AI) in Physical Education (PE), examining its capacity to enhance instructional quality and student engagement. It also critically addresses ethical concerns and implementation challenges across culturally diverse and resource-variable contexts.

Methods: This qualitative study employed the Sample, Phenomenon of Interest, Design, Evaluation, and Research type (SPIDER) framework to systematically retrieve and synthesize 41 peer-reviewed articles from academic databases including ScienceDirect, Elsevier, ProQuest, ERIC, Taylor & Francis, and UNESCO. The studies were preliminarily screened and then appraised for quality utilizing the Mixed Methods Appraisal Tool (MMAT). Lastly, thematic synthesis was done in a bid to discern significant patterns and results regarding the research point of emphasis.

Results: Thematic synthesis identified six key themes in the integration of AI in PE: performance optimization, individualized learning, data-informed assessment, engagement and motivation, improvement in the educational process, and ethical challenges in implementation. Whereas AI shows considerable promise in remodeling PE practices, implementation remains differential across locations. Inhibitors like restricted access to equipment and technology, ethical concerns, and differences in institutional emphasis persist in dictating the course of AI implementation. Comparative analysis across locations also served to emphasize differences in approach and areas of emphasis in AI-infused pedagogy.

Conclusion: Effective AI integration in PE is contingent upon context-aware design, improved instructor readiness, and effective ethical leadership. Inclusive professional development and culturally informed frameworks ought to initiate balanced and resilient use.

Keywords: Artificial Intelligence, Physical Education and Training, Meta-Synthesis, Pedagogical Innovation, Ethics, Global Trends

**Corresponding author:*
Zainab Gorzinmataee, Department of Educational Science, Farhangian University, Postal code: 14665-889, Tehran, Iran
Tel: +98 9125351482
Email: zgorzinm@cfu.ac.ir

Please cite this paper as:
Gorzinmataee Z, Rezaee FZ, Farrokhnia MR. Meta-Synthesis of Qualitative Research on Artificial Intelligence in Physical Education: Performance, Ethics, and Global Trends. Interdiscip J Virtual Learn Med Sci. 2025;16(3):2-20. doi: 10.30476/ijvlms.2025.107252.1339.

Received: 24-05-2025
Revised: 10-08-2025
Accepted: 01-09-2025

Introduction

Pursuits of educational quality and effectiveness are understood as an overriding concern for educational systems around the world and the embedding of technology as a routine teaching method and policy initiative (1). Within this evolving landscape, Artificial Intelligence (AI) has emerged as a transformative force, offering the potential to redefine Physical Education (PE) through data-driven personalization and enhanced student engagement (2). Research findings indicate that AI integration in PE has led to measurable improvements in both instructional quality and learner motivation (3). Tools such as computer vision and wearable sensors now enable real-time biomechanical feedback (4), while AI-powered platforms support targeted instruction, personalized training programs, and precise performance assessments (5-7). These innovations have shown promise in boosting intrinsic motivation and supporting athletic development among students (8).

Despite these advancements, the technological shift toward AI in PE remains fraught with three core tensions that complicate sustainable adoption. The first challenge is the privacy paradox. While deep learning models rely on extensive biometric data, concerns regarding student surveillance and data protection remain pressing (9), particularly in immersive Virtual Reality (VR) environments, where motion capture technologies may infringe on personal privacy boundaries (10).

The second challenge is the competency gap. There is a notable disparity between the technical capabilities of AI systems and the readiness of educators to implement them effectively (11, 12). This gap is further exacerbated by insufficient professional development infrastructure, which limits meaningful adoption even in technologically equipped settings (2, 8).

The third concern is the equity divide. While well-funded institutions take advantage of AI-enhanced instruction, under-resourced schools continue to face barriers in adopting even basic digital platforms (13).

These interconnected challenges reveal deep systemic limitations that threaten the scalability and sustainability of AI in PE.

In addition to logistical and infrastructural challenges, the cultural and ethical aspects of AI implementation also raise significant concerns. Perceptions of AI are influenced by the sociocultural context; for instance, parental expectations regarding student data privacy differ notably between Middle Eastern and European regions (1), while understandings of algorithmic fairness often diverge between collectivist and individualist societies (14). Ethical frameworks for the use of AI in education are primarily based on Western norms and often remain mostly theoretical (15), providing little practical guidance for institutions in developing countries. This issue is particularly concerning since almost 70% of these institutions do not have sufficient systems to deploy AI safely and in compliance with regulations (2). Scholars also caution against more general risks, such as data privacy breaches (16), algorithmic bias in movement analysis (17), and unequal access to AI infrastructure across educational systems (18). Together, these issues challenge the assumption that AI-driven PE is neutral and universally beneficial. Instead of viewing AI as a panacea, its role must be critically reassessed as a complex and context-dependent intervention. This reevaluation requires careful alignment with curricular goals, preservation of teacher agency (19), and the incorporation of culturally responsive design (20).

This study aimed to conduct a qualitative meta-synthesis of AI integration in PE regarding instructional performance, ethical issues, and global implementation trends. The main objective was to critically examine how AI technologies influence teaching quality and student engagement in PE, identify institutional and cultural barriers to effective adoption, assess PE instructors' technological readiness, and explore ethical challenges within diverse educational contexts. To achieve these goals, four research questions were developed, with the themes extracted

from the meta-synthesis providing enhanced understanding and clarification:

1. How does AI-driven pedagogy influence the quality of PE instruction and student engagement?
2. What are the primary barriers preventing the effective integration of AI in PE curricula, particularly in multicultural and resource-limited settings?
3. How can targeted professional development programs enhance PE instructors' technological readiness for AI adoption?
4. What ethical concerns arise from AI-based PE tools, and how can they be addressed using culturally adaptive frameworks?

Methods

Study Design

This study employed a qualitative meta-synthesis methodology to investigate the role of AI in PE, aiming to produce deeper conceptual understanding by interpreting and synthesizing findings from existing studies. Unlike systematic literature reviews that generally compile quantitative data to evaluate effect sizes or intervention results, meta-synthesis focuses on achieving conceptual richness, developing theories, and reinterpreting meanings across different studies, often based on methodologies such as grounded theory, ethnography, and phenomenology (21, 22). A structured and transparent screening process was designed to support the inclusion of peer-reviewed and thematically relevant literature. Guided by established qualitative meta-synthesis principles (22), the study followed a multi-phase procedure involving article selection, full-text appraisal, and evaluation based on inclusion and exclusion criteria. In accordance with a recognized synthesis framework (21), thematic synthesis was employed to integrate findings from the selected studies, enabling the identification of recurring patterns, conceptual tensions, and emergent thematic structures (23). This interpretive synthesis facilitated a rich, theory-informed understanding of AI's pedagogical applications and ethical implications in PE, highlighting implementation gaps and evolving trends across diverse educational and cultural contexts.

Search Strategy

The study systematically identified research addressing AI applications in PE through a rigorous meta-synthesis framework. The SPIDER tool, which encompasses Sample, Phenomenon of Interest, Design, Evaluation, and Research type, was employed to develop the inclusion filters during the screening process (24). The search included three main categories: (a) qualitative research focused on experiential and interpretive aspects of AI-enhanced pedagogy; (b) quantitative studies with phenomenological implications; and (c) mixed-methods designs integrating narrative and empirical insights. Data collection was conducted through academic databases including ScienceDirect, Elsevier, ProQuest, ERIC, Taylor & Francis, and UNESCO. The keyword search employed combined semantic categories such as *('artificial intelligence' OR AI OR 'machine learning' OR 'intelligent systems' OR 'educational technology' OR EdTech) AND ('physical education' OR PE OR 'sports education' OR 'sports pedagogy' OR 'movement education' OR 'school-based physical activities' OR 'athletic instruction' OR 'sports training' OR 'coaches' OR 'physical literacy' OR 'motor learning' OR 'fitness education')*. These search strategies were designed to identify studies aligned with the conceptual scope of meta-synthesis, emphasizing instructional models, technological innovations, and ethical implications within PE. The 2020-2024 timeframe was selected to capture recent pedagogical shifts driven by increased adoption of AI-based tools in PE. This period reflects significant integration of intelligent tutoring systems, adaptive platforms, and interactive learning environments. Selecting studies from this span enabled focused qualitative analysis of emerging trends in AI-based PE (25).

Selection Criteria

Eligible studies included full-text, peer-

reviewed journal articles published in English from 2020 to 2024. The papers had to present primary data derived from empirical research conducted in PE settings. Inclusion was contingent on studies showing clear methodological transparency and relevance to the review's conceptual framework. Publications were included if they addressed experiential, interpretive, or technology-enhanced dimensions of AI-integrated pedagogy, performance enhancement, and ethics in PE. Additionally, these works needed to align with the thematic focus of the established synthesis framework.

The initial search yielded only abstracts and titles. Duplicate records, clearly irrelevant studies, and those not meeting the predefined inclusion criteria were excluded. In accordance with a meta-synthesis framework (21), the next phase involved full-text screening to determine whether the studies employed qualitative, quantitative (with phenomenological relevance), or mixed-method approaches to investigate AI-enhanced pedagogy in PE. The specific methodological orientation; such as grounded theory, phenomenology, or ethnography was not used as an exclusion criterion, given their shared interpretive focus on meaning-making and experiential understanding. Studies based on predominantly quantitative designs with minimal qualitative supplementation were excluded, as their analytical scope did not support the depth of interpretation required to explore participants lived experiences with AI-integrated pedagogy, performance enhancement, and ethics in PE contexts.

Quality Assessment of the Included Documents

To assess the methodological rigor and transparency of the selected studies, the Mixed Methods Appraisal Tool (MMAT), version 2018, was applied (26). MMAT provides a structured framework for evaluating qualitative, quantitative, and mixed-methods research across five study categories, each assessed through five core criteria related to sampling, data collection, analysis, interpretation, and integration. Each of the 45 articles was independently assessed by three researchers with expertise in technology-enhanced pedagogy, followed by peer validation from an external reviewer to enhance credibility. Studies were excluded if they failed to meet 3 out of 5 key MMAT indicators; such as lacking empirical grounding, omitting sampling details, or failing to justify analytical choices. These shortcomings undermined the interpretive trustworthiness necessary for inclusion in the meta-synthesis.

Screening and Data Collection Process

A structured screening and data collection process was conducted to identify conceptually relevant qualitative studies on AI integration in PE. Initial searches were guided by the SPIDER tool to target studies involving relevant samples (e.g., educators/students), the phenomenon of AI-enhanced pedagogy, qualitative designs or methods, evaluative insights into learning experiences, and empirical research types. Titles and abstracts were screened for alignment with the study's focus and guiding questions, followed by full-text evaluations emphasizing methodological transparency, contextual richness, and thematic relevance. Screening decisions were collaboratively reviewed and cross-validated to ensure credibility and conceptual coherence across diverse instructional settings.

Data Extraction and Analytical Framework

Data extraction and analysis followed a systematic and interpretive approach, utilizing thematic checklists alongside the constant comparison method to identify recurring concepts across the selected qualitative studies. Study characteristics, including publication year, methodology, participant profiles, and research focus were recorded. Key findings, including participant quotes and thematic interpretations, were imported into NVivo, a leading qualitative data analysis software, for line-by-line inductive coding. Using a well-established

coding framework (27), initial concepts were generated through open coding, organized into thematic clusters during axial coding, and synthesized into broader analytical insights via selective coding. The frequency and consistency of emergent patterns across studies further reinforced the descriptive themes, and a second round of narrative reading confirmed contextual relationships. This iterative process produced a hierarchy of core and descriptive themes centered on AI-integrated pedagogy, performance enhancement, and ethics in PE, aligning with the conceptual goals of the meta-synthesis.

To identify relevant literature for the meta-synthesis, a multi-stage search and screening process was conducted across six major academic databases: ScienceDirect (n=87), Elsevier (n=68), ProQuest (n=170), ERIC (n=92), Taylor & Francis (n=65), and UNESCO (n=21).

Stage 1: Initial Screening Using SPIDER

The SPIDER tool was employed to guide the initial screening, particularly suited for qualitative and mixed-methods research. This approach allowed for a focused retrieval of studies that addressed experiential, interpretive, and context-rich data.

Out of the total pool, 45 articles were identified as potentially relevant based on SPIDER criteria. These included studies involving teachers, students, and educational experts, focusing on AI integration, personalization, motivation, ethics, and assessment in PE contexts.

Stage 2: Quality Confirmation Appraisal Using MMAT

To enhance the credibility and methodological rigor of the selected studies, MMAT was applied during the second stage of the synthesis. This step involved evaluating each article's empirical grounding, design coherence, data collection clarity, and the analytical transparency.

Following this appraisal, 41 studies met the final inclusion criteria and were retained for in-depth thematic analysis. The selection and screening process is illustrated in Figure 1.

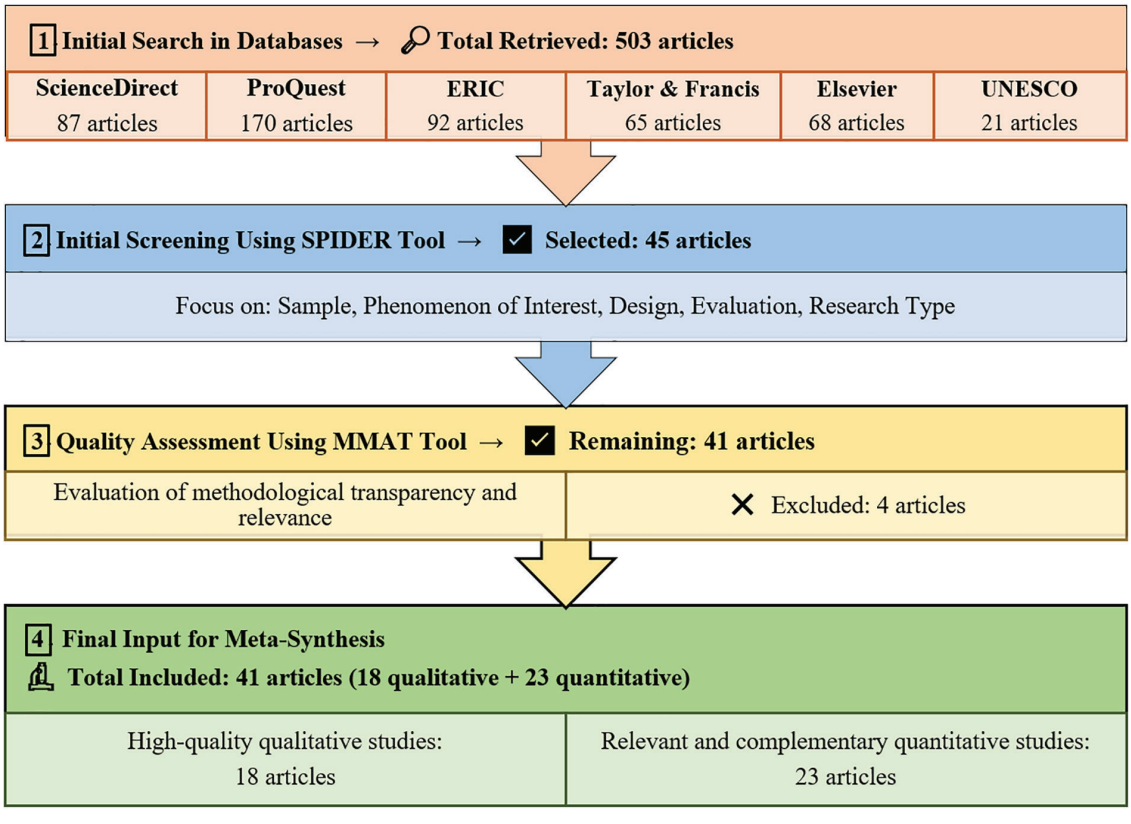

Figure 1: Flowchart of Article Selection and Screening for Meta-Synthesis. MMAT: Mixed Methods Appraisal Tool; SPIDER: Sample, Phenomenon of Interest, Design, Evaluation, and Research type.

Inclusion of Quantitative Studies

The initial preference was to focus on qualitative studies because of their depth and contextual detail; however, the topic of AI in physical education required the inclusion of certain quantitative studies. These quantitative studies offered strong generalizability, robust statistical analysis, and evidence-based findings that aligned well with the synthesis's thematic objectives. Although only few quantitative studies were incorporated (4, 28), they made significant contributions to understanding motivation and stress reduction through AI tools, with their methodological rigor and thematic relevance justifying their inclusion. Similarly, longitudinal and cohort studies examining machine learning in performance enhancement and injury prevention enriched themes related to real-time feedback, adaptive learning, and ethical considerations (2, 5, 29). Despite being mainly quantitative, these studies closely aligned with themes of personalization, motivation, and responsible AI integration.

Conversely, four studies (17, 30-32) were excluded following methodological appraisal. Although they offered conceptual or technical insights, they lacked sufficient empirical grounding or participant-centered data required for thematic synthesis. Their exclusion was solely based on the synthesis criteria and did not undermine their wider academic significance. This selective approach maintained methodological diversity while ensuring the synthesis remained thematically consistent, effectively balancing qualitative detail with appropriate quantitative evidence.

Results

The synthesis initially reviewed 45 conceptually relevant studies. After conducting a methodological appraisal using the MMAT, four studies were excluded due to inadequate quality scores. The remaining 41 studies were selected for thematic analysis, forming the basis of the interpretive synthesis. Methodologically, the included studies presented a diverse yet uneven landscape. Qualitative designs, particularly interviews, Delphi techniques, and content analysis, were the most prominent, offering rich insights into pedagogical, cultural and ethical dimensions of AI integration in PE. Quasi-experimental and mixed-methods approaches also contributed valuable understanding regarding performance, engagement, and contextual adaptation. While the studies spanned multiple regions, geographic details were condensed to maintain the thematic focus. Table 1 summarizes all the 45 studies assessed, including those excluded, and outlines their methodological features, geographic origins, and conceptual relevance. This comprehensive overview supports transparency and contextualizes the interpretive findings.

Table 1: An overview of studies highlighting methodological features and conceptual insights on AI integration in physical education

No.	Authors (Ref No.)	Methodology	Estimated Criteria Met (out of 5)	Key Ideas	Year / Country	Included
01	Saiz-González and colleagues (1)	Qualitative (Survey)	4	Digital integration interest, adoption barriers, policy challenges, implementation strategies.	2024 Spain	✓
02	Krstić and colleagues (2)	Quantitative (Longitudinal)	4	ML for performance optimization, injury prevention, real-time feedback, big data.	2023 Serbia	✓
03	KK K (3)	Mixed-Methods	5	Adaptive learning, performance simulation, cultural resistance.	2024 South Korea	✓

No.	Authors (Ref No.)	Methodology	Estimated Criteria Met (out of 5)	Key Ideas	Year / Country	Included
04	Bruno and colleagues (4)	Quasi-Experimental	3	Wearable sensors for personalized feedback, data-driven planning, reduced student stress.	2024 Spain	✓
05	Wang and Wang (5)	Quantitative (Field Experiment)	4	AI wearables for personalized PE, data-driven engagement strategies.	2024 China	✓
06	Xu and colleagues (6)	Qualitative synthesis approach	5	AI + wearables for adaptive PE, real-time feedback, personalized learning.	2024 China	✓
07	Wang and Du (7)	Quantitative (design-based experimental)	4	ML and loT algorithms for fitness data analysis and personalized PE recommendations.	2022 China	✓
08	Maňenová and colleagues (8)	Quasi-Experimental	4	Mobile apps in PE for motivation, healthy competition, teacher training in digital tools.	2022 Czech Republic	✓
09	Hu and Li (9)	Quasi-Experimental	4	Smart trackers & apps for personalized programs, real-time feedback, tech integration.	2024 China	✓
10	Su and colleagues (10)	Quasi-Experimental	5	Diverse training scenarios, real-time performance monitoring, skill-specific feedback.	2024 China	✓
11	Yu and Wang (11)	Quasi-Experimental	5	Data-driven evaluation, smart tech integration, personalized instruction.	2024 China	✓
12	Naughton and colleagues (13)	Qualitative (conceptual analysis)	4	Human–machine interaction, socio-technical complexity, technological opportunities, ethical and organizational challenges.	2024 Australia	✓
13	Genç Neşe (14)	Narrative Review	4	AI in athlete performance, teacher assistance, ethical/ technical issues, future trends.	2023 Turkey	✓
14	Lee and Lee (15)	Theoretical (Conceptual)	5	Personalized education, AI-driven student assessment, future of sports/education research.	2021 South Korea	✓
15	Zhao and colleagues (16)	Experimental (RCT)	5	Digital games for motivation, interactive learning, sustained physical activity.	2024 China	✓
16	Sadr and colleagues (17)	Quantitative (Algorithm Testing)	2	Deep learning for movement analysis, educational robots, smart athlete training.	2024 Iran	✗
17	Modra and colleagues (18)	Mixed-Methods	4	Digital tools in PE for engagement, challenges/ opportunities of tech integration.	2021 Slovakia	✓

No.	Authors (Ref No.)	Methodology	Estimated Criteria Met (out of 5)	Key Ideas	Year / Country	Included
18	Killian and colleagues (19)	Qualitative (Interviews)	5	AI in teacher training, pedagogical/ethical considerations.	2023 USA	✓
19	Rosa JP (20)	Qualitative (Narrative Review)	4	Personalization, digital inclusion, intelligent coaching, virtual rehabilitation, assistive feedback, barrier reduction, empowering access.	2024 Brazil	✓
20	Zhou and colleagues (25)	Qualitative (Content Analysis)	5	Sports performance analysis, healthcare integration, privacy/security concerns.	2024 China	✓
21	Gabarron and colleagues (28)	Experimental (RCT)	4	AI recommender systems and chatbots for motivation, gamification, long-term habit formation.	2024 Norway	✓
22	Mishra and colleagues (29)	Quantitative (Cohort Study)	4	AI analytics for injury prevention, smart technologies for performance/safety optimization.	2024 India	✓
23	Dergaa and colleagues (30)	Descriptive (Position Paper)	2	GPT-4 in training planning, accuracy/safety evaluation, human-AI interaction challenges.	2024 Qatar	✗
24	Kaswan and colleagues (31)	Descriptive (Framework Proposal)	2	Adaptive AI tutoring, bias/ privacy risks, responsible implementation.	2024 India	✗
25	Rahmani and Majedi (32)	Quantitative (Simulation)	2	AI for athletic performance, predictive analytics, injury prevention, fan engagement.	2024 Iran	✗
26	Almusawi and colleagues (33)	Survey	4	Teacher's Readiness, Positive Attitudes, Need for Institutional Support	2021 Bahrain	✓
27	Cudicio and colleagues (34)	Mixed-Methods	4	AI personalization in PE, ethical concerns, teacher's role in AI-integrated environments.	2024 Italy	✓
28	Molavian and colleagues (35)	Cross-Sectional	5	Age-specific AI analysis, performance evaluation, adaptive functional activities.	2022 Iran	✓
29	Hsia and colleagues (36)	Qualitative (Delphi Study)	5	AI assessment tools, privacy, fairness, personalized learning.	2024 Taiwan	✓
30	Khanal and colleagues (37)	Systematic Review	4	AI (computer vision, contactless technology) for physical exercises.	2022 Portugal	✓
31	Li and Sun (38)	Experimental (Pilot Study)	4	VR in PE (motion modeling, simulations), AI for movement analysis, student participation.	2024 China	✓

No.	Authors (Ref No.)	Methodology	Estimated Criteria Met (out of 5)	Key Ideas	Year / Country	Included
32	Cao and colleagues (39)	Mixed-Methods	4	AI + big data for PE personalization, feedback, engagement, reform, AI, data, density, reliability.	2022 China	✓
33	Li & Xue (40)	Quantitative (Data Mining)	4	AI for dynamic tracking in teaching, big data analytics to address low information extraction.	2022 China	✓
34	Liu W (41)	Qualitative (Meta-Analysis)	5	Motivational theories (SDT, AGT) in sports, autonomy/ competence/relatedness for progress.	2024 China	✓
35	Masters K (42)	Qualitative (Expert Review)	5	Ethical AI integration (fairness, accountability), strategies for educators.	2023 USA	✓
36	Mokmin N (43)	Experimental (RCT)	5	AI virtual fitness trainer (IVFIT), unsupervised motivation/participation, performance assessment.	2020 Malaysia	✓
37	Neji and colleagues (44)	Quasi-Experimental	4	AI chatbots for instant feedback, personalized skill enhancement, student engagement.	2023 Tunisia	✓
38	Oh and colleagues (45)	Experimental (Pilot Study)	5	Advanced AI chatbots for sustainable PA, adaptive human-AI interaction, digital health tools.	2021 South Korea	✓
39	Reis and colleagues (46)	Qualitative (Focus Groups)	5	AI for injury prediction/ performance, ethical complexities of integration.	2024 Portugal	✓
40	Su and colleagues (47)	Qualitative (Interviews)	5	Personalized learning, teaching efficiency, ethical issues, resistance to change.	2024 China	✓
41	Tang X (48)	Experimental (RCT)	4	VR/AR for self-learning, predictive factor analysis, motivation enhancement.	2024 China	✓
42	Tariq and colleagues (49)	Action Research	4	Limitations of traditional PE assessments, innovation (portfolios, peer-assessment).	2024 Pakistan	✓
43	Tian and Guo (50)	Mixed-Methods	4	AI + gamification (AR, smart analytics) for engagement and instant feedback.	2024 China	✓
44	Wang and colleagues (51)	Qualitative (Delphi Study)	4	Teaching process improvement, uniform program critiques, teacher training needs.	2024 China	✓
45	Young and colleagues (52)	Quantitative (Validation Study)	4	Physical literacy assessment (motor competence, understanding, confidence).	2021 Canada	✓

Table 2: Synthesized themes from thematic synthesis of AI in physical education

	Synthesized Themes	Descriptions	Key Concepts	Supporting References
1	AI for Performance Optimization	Application of AI to analyze sports movements, predict injury risks, and optimize training plans using sensor-based feedback and predictive models.	Biomechanics analysis, predictive analytics, dynamic training adjustment	(2, 19)
2	Personalized and Adaptive Learning	AI systems that tailor instruction to individual learners through adaptive algorithms, chatbots, and immersive technologies like VR/AR.	LMS integration, virtual tutors, gamified simulations	(39, 44, 48)
3	Data-Driven Assessment	Use of automated tools and wearables to assess motor skills, fitness levels, and physical literacy in real time.	Smart assessment, continuous monitoring, literacy evaluation	(33, 36, 37, 52)
4	Engagement and Motivation	AI-enhanced strategies such as gamification, behavioral nudges, and interactive platforms to increase student motivation and participation.	Leaderboards, AR experiences, motivational chatbots	(6, 25, 28)
5	Educational Process Improvement	AI tools that assist teachers in lesson planning, resource management, and pedagogical decision-making through data analytics.	Teacher support, time efficiency, data-informed pedagogy	(1, 44, 51)
6	Ethical and Implementation Challenges	Issues related to algorithmic bias, data privacy, and the evolving role of educators in AI-integrated learning environments.	Fairness, privacy risks, human-AI collaboration	(1, 25, 42)

Thematic Synthesis Overview

To synthesize the findings across the selected studies, a thematic synthesis approach was employed following the framework proposed by Thomas and Harden (23). This method involved three iterative stages: first, extracting descriptive codes from the primary data reported in each study (e.g., AI applications, pedagogical strategies, ethical concerns); second, organizing these codes into analytical categories that reflect shared patterns and conceptual similarities; and third, generating higher-order synthesized themes that capture the overarching constructs emerging across the literature. This process enabled the identification of six core themes related to AI integration in PE: performance optimization, personalized learning, data-driven assessment, engagement and motivation, educational process improvement, and ethical implementation challenges. These themes are outlined in Table 2, along with the coding framework and essential references that support each synthesized construct.

Discussion

Through thematic synthesis of 41 studies, six key conceptual themes were identified that encapsulate the multifaceted role of AI in PE. Each theme, ranging from performance optimization to ethical implementation, offers a distinct lens through which the core research questions can be further explored and addressed. These synthesized concepts not only reflect the current landscape of AI integration in PE but also serve as strategic entry points for deeper inquiry. By connecting each theme to specific educational challenges, this framework clarifies and addresses key study concerns, offering a more nuanced understanding of how AI can enhance physical literacy, instructional quality, and equitable access in educational settings.

RQ1: To address the first research question, three synthesized themes were primarily drawn upon: AI for Performance Optimization, Engagement and Motivation, and Data-Driven Assessment.

Together, these themes illustrate how AI

technologies are reshaping PE by enhancing instructional precision, fostering immersive engagement, and enabling data-informed teaching strategies.

1. Precision Personalization of Instruction: This mechanism directly corresponds to the theme "AI for Performance Optimization". AI technologies such as wearable sensors, motion analysis systems, and machine learning platforms enable hyper-personalized feedback, replacing the traditional one-size-fits-all model. Real-time biomechanical corrections (17) and dynamic training adaptations allow educators to address individual differences in physical ability and progress. This level of personalization reflects the principles of Vygotsky's Zone of Proximal Development, positioning AI as a "digital scaffold" that bridges current and potential competencies (34). Such personalization not only enhances instructional precision but also promotes student confidence and autonomy.

2. Immersive and Motivational Engagement: This mechanism aligns with the theme "Engagement and Motivation". Gamified AI tools, including VR simulations, AR-enhanced challenges, and adaptive chatbots, have proven to be as powerful catalysts for intrinsic motivation. Research studies demonstrate that real-time encouragement, competitive dynamics, and interactive feedback foster deeper engagement (16, 45). However, some studies warn that gamification must be pedagogically grounded to avoid distracting from core learning objectives (50). When applied thoughtfully, these tools have the potential to shift PE from a passive activity to a dynamic and emotionally engaging experience.

3. Data-Driven Instructional Improvement: This mechanism reflects the theme "Data-Driven Assessment". AI's analytical capabilities allow educators to tailor instruction based on real-time data. Automated assessments help identify skill gaps (36), while predictive analytics optimize group dynamics and learning trajectories (10). These insights support both immediate instructional decisions and long-term curriculum planning (39), enhancing the overall quality of teaching and learning.

Despite these benefits, the synthesis also highlights challenges that intersect with the theme "Ethical and Implementation Challenges". Educators must redefine their roles, not as passive recipients of AI recommendations, but as critical facilitators who integrate technology within broader pedagogical frameworks (6). Excessive dependence on automation can undermine the quality of instruction and erode student trust (33). Additionally, differences in infrastructure and digital preparedness could worsen current achievement disparities if inclusive policies are not implemented (1).

In summary, AI-driven pedagogy shows strong potential to improve PE instruction and student engagement by fostering personalized, interactive, and evidence-based learning. However, its long-term success depends on thoughtful integration, teacher agency, and equity-driven deployment. Future longitudinal research is needed to evaluate whether these engagement gains lead to sustained physical literacy and holistic development.

RQ2*:* To address the second research question, three synthesized themes were primarily drawn upon: Ethical and Implementation Challenges, Educational Process Improvement, and Data-Driven Assessment.

Together, these themes highlight the key barriers to AI integration in PE, including infrastructural limitations, cultural misalignment, and gaps in teacher preparedness. They emphasize that successful implementation requires not only technological access but also inclusive, context-sensitive educational strategies.

1. Infrastructural and Resource Constraints: This barrier is closely linked to the theme "Ethical and Implementation Challenges", as well as "Educational Process Improvement," since it reflects systemic limitations that hinder equitable access to AI technologies in PE. Successful AI implementation in PE requires a robust

infrastructure, yet many underfunded schools lack basic access to digital resources. Studies have highlighted critical shortages in equipment such as internet bandwidth, sensors, and VR headsets, making advanced tools like motion capture systems or adaptive analytics platforms practically inaccessible (1, 4, 5, 18). Moreover, even where AI is initially deployed, sustainability remains elusive due to maintenance costs and limited technical support (30). These patterns raise concerns that AI may deepen rather than bridge digital divides, favoring institutions with stronger funding and technical infrastructures (39).

2. Cultural and Pedagogical Misalignment: This issue aligns with "Ethical and Implementation Challenges", highlighting how cultural norms and rigid curricula can conflict with AI-driven approaches in diverse educational settings. In many regions, particularly those with deeply rooted pedagogical traditions or standardized curricula, AI faces resistance not only as a technical innovation but also as a cultural intrusion. In East Asian school systems, AI is often deprioritized due to its perceived misalignment with rigid, exam-driven PE programs (3). Similarly, hesitation has been observed in European contexts, where AI is seen as undermining teacher–student relational dynamics (20). Cultural friction is also evident in tool design; Western-built chatbots have shown limited relevance in Middle Eastern settings, where language, gender norms, and classroom structures diverge significantly from design assumptions (13). For instance, the effective implementation of AI in Malaysia depended greatly on thorough contextual adaptation, a critical process that is often neglected in global applications (43).

3. Gaps in Teacher Preparation and Professional Trust: This challenge relates to both "Ethical and Implementation Challenges" and "Data-Driven Assessment," emphasizing the lack of teacher readiness and skepticism toward algorithmic decision-making in PE instruction. Teachers play a pivotal role in mediating between AI capabilities and pedagogical goals, yet many feel ill-equipped or skeptical about the technology. Educators often lack formal training in AI, which can lead to misuse or abandonment of technological tools (19, 42). Even among trained professionals, reconciling algorithmic outputs with core educational principles like autonomy, fairness, and formative assessment, continues to be difficult (36). Studies conducted in Latin America and North Africa reveal that some educators perceive AI as a threat to their professional identity, particularly in its role in student performance evaluation (30, 46).

These barriers underscore that AI integration in PE is not solely a technological challenge but also a social, cultural, and institutional one. If concerns related to equity, teacher empowerment, and cultural responsiveness are not addressed, AI could perpetuate the inequalities it seeks to eliminate. Future implementation efforts should prioritize pilot testing in diverse environments, integrate community co-design frameworks (20), and support low-tech, context-appropriate alternatives such as SMS-based systems (32). Ultimately, for AI to enhance PE equitably, it must be embedded within inclusive, sustainable, and locally grounded strategies.

RQ3: To address the third question, three synthesized themes were primarily drawn upon: Educational Process Improvement, Ethical and Implementation Challenges, and Data-Driven Assessment.

Together, these themes emphasize that enhancing teachers' technological readiness for AI requires well-designed professional development (PD) programs, institutional support, and training that helps educators interpret and apply AI-generated data effectively in PE settings.

1. Persistent Deficits in Current Training: This issue is closely related to the themes "Educational Process Improvement" and "Ethical and Implementation Challenges," as it reflects gaps in how professional development is currently designed and delivered. Many existing PD programs

fall short in preparing PE instructors for meaningful AI integration. Most training initiatives focus narrowly on operational skills, often overlooking pedagogical purpose and ethical considerations (42, 51). Without a balanced emphasis on human–AI collaboration, educators may face marginalization within increasingly automated learning environments (6, 19). Furthermore, one-off workshops with limited follow-up contribute to high attrition rates and minimal classroom impact (27).

2. Features of Effective Professional Development: This point connects strongly to the themes "Educational Process Improvement" and "Data-Driven Assessment," as it focuses on how PD can support meaningful and confident use of AI in teaching. Successful PD initiatives share several traits: they embed AI within authentic teaching practices, emphasize critical reflection, and promote collaborative learning. Integrating AI into lesson planning has been shown to improve tool adoption (39), while incorporating ethical reflection, such as bias awareness and data privacy can foster teacher confidence (25, 36). Peer-driven communities of practice also play a key role in encouraging sustained use and pedagogical exploration (37).

3. Implementation Realities and Cultural Relevance: This challenge relates to the themes "Ethical and Implementation Challenges" and "Educational Process Improvement," as it highlights the external and cultural factors that affect how PD programs are received and applied. Even well-designed PD programs face external pressures that limit their impact. Overloaded teaching schedules often prevent teachers from fully implementing their training (18), and professional development models centered on Western perspectives, which are not culturally adapted, hold limited relevance in non-Western settings (3), leading to gaps between training and real classroom conditions. Limited evaluation mechanisms have also been identified; most programs assess success based on perceived confidence rather than actual classroom integration (28).

In summary, bridging the readiness gap between fast-evolving AI tools and slow-moving teacher training systems requires reimagining PD as an ongoing, reflexive, and context-sensitive process. Such programs must balance technical competence with pedagogical insight and ethical engagement; positioning educators not as passive adopters, but as critical agents in AI-enhanced instruction (33).

RQ4: To address the last question, three synthesized themes were primarily drawn upon: Ethical and Implementation Challenges, Data-Driven Assessment, and Educational Process Improvement.

Together, these themes highlight that while AI tools offer new opportunities in PE, they also raise serious ethical concerns, especially around data privacy, bias, and teacher–student autonomy. Addressing these issues requires culturally adaptive frameworks that respect local values and ensure responsible use of technology.

1. Data Sensitivity and Privacy Vulnerabilities: This concern is closely tied to the themes "Ethical and Implementation Challenges" and "Data-Driven Assessment," as it involves how student data is collected, stored, and used in AI-based PE tools. AI-powered PE systems often rely on biometric and behavioral inputs to offer personalized feedback. However, concerns about surveillance, data misuse, and stigmatization are prevalent across studies. Commercial platforms have been criticized for opaque data practices and third-party sharing (25), while parental opposition to student tracking varies widely across cultural contexts (36). Poor data governance, as seen in cases of unauthorized access to health information (46), disproportionately affects marginalized learners. These findings highlight the urgent need for culturally sensitive data policies that respect community values and ensure consent-driven usage.

2. Algorithmic Bias and Structural Inequality: This issue relates to the themes "Ethical and Implementation Challenges" and "Educational Process Improvement,"

as it highlights how AI can unintentionally reinforce social and cultural inequalities. AI systems can perpetuate normative assumptions, unintentionally excluding learners who deviate from idealized models. Studies document higher error rates for students with obesity (17), gender-biased chatbot responses (28), and body type misclassifications in South Asian populations (3). While debiasing techniques offer technical relief (42), scholars stress the importance of interdisciplinary responses that address the social foundations of bias through locally rooted, inclusive frameworks (34).

3. Erosion of Human Agency and Cultural Pedagogies: This concern is strongly linked to the themes "Ethical and Implementation Challenges" and "Educational Process Improvement," as it deals with how AI may undermine teacher autonomy and cultural diversity in education. As AI becomes more common in PE, there's a risk that teachers and students rely too heavily on automated decisions. Studies show that educators sometimes trust algorithmic feedback even when it is inaccurate; a phenomenon known as "automation bias" (6, 33). Globally designed tools like IVFIT (Intelligent Virtual Fitness Instruction and Training) (43) may unintentionally replace local teaching traditions and promote cultural dominance. In addition, gamified AI systems can create addictive feedback loops that affect young learners' ability to self-regulate (16), raising concerns about long-term autonomy and well-being (11).

To mitigate these ethical challenges, scholars advocate for culturally adaptive frameworks that center participation and contextual integrity. Co-design models involving teachers (20), community-led ethical audits and sandboxes (1), and algorithmic impact assessments attuned to local values (36, 13) offer pathways for responsible integration. Most critically, fostering critical AI literacy among educators (19) and cultivating digital citizenship in students (37) are essential to building reflective, empowered users capable of navigating and shaping AI's role in PE.

Limitations and Suggestions

While this meta-synthesis provides valuable insights into how AI is being used in PE, it has some limitations. The four-year publication window may not reflect long-term changes in AI development, and focusing only on English-language sources could miss important innovations from non-English-speaking regions. Most of the studies rely on mixed or quantitative methods, which may highlight technical features but overlook deeper pedagogical and ethical issues. Also, the regional focus of the research may hide challenges faced in low-resource or culturally diverse settings.

To overcome these gaps, future research should include longer-term studies that combine data analysis with real classroom experiences. Including work from a wider range of cultural contexts will help uncover local barriers and more effective ways to implement AI. Using participatory methods like co-designed tools and community-based frameworks, can ensure that AI is ethically grounded and supports teacher agency. Finally, education policies should aim for flexible guidelines that promote innovation while protecting equity and teaching quality across different school systems.

Conclusion

This meta-synthesis examined 41 conceptually rich studies to explore the integration of AI in PE, focusing on pedagogical innovation, educator readiness, equitable implementation, and ethical challenges. Findings across four interpretive domains reveal that AI-enhanced PE holds transformative potential, but its success hinges on thoughtful design, contextual responsiveness, and educator empowerment.

AI-driven pedagogy can elevate instructional quality and learner engagement through personalization, real-time feedback, and immersive experiences. Yet, its integration is uneven, especially in multicultural and resource-limited settings due to infrastructural constraints, cultural misalignment, and limited teacher

preparation. However, the adoption of these methods is inconsistent, particularly in diverse and resource-poor environments, because of issues like inadequate infrastructure, cultural differences, and insufficient teacher training. It is essential to reimagine the role of educators; they should be viewed not as passive adopters of technology but as reflective, critical agents who mediate its use. Professional development must evolve into sustained, participatory, and ethically grounded processes that align AI tools with local needs and pedagogical values. In summary, AI's role in PE should not be defined solely by its novelty but by its capacity to foster meaningful, inclusive, and sustainable learning. Future research should investigate the long-term impacts on physical literacy, student autonomy, and the collaborative relationship between educators and AI, particularly through longitudinal and cross-cultural studies.

Abbreviations

AI: Artificial Intelligence
IVFIT: Intelligent Virtual Fitness Instruction and Training
MMAT: Mixed Methods Appraisal Tool
PD: Professional Development
PE: Physical Education
SPIDER: Sample, Phenomenon of Interest, Design, Evaluation, and Research type

Acknowledgments

We sincerely acknowledge the valuable contributions of our colleagues and members of the academic community whose insightful feedback and constructive critiques enhanced both the analytical depth and scholarly rigor of this research. We also acknowledge that AI assistance was used to correct the grammar in some sections of the manuscript.

Authors' Contribution

ZG, FR, and MF collaboratively conceptualized the study and developed its methodology. ZG conducted the meta-synthesis, led the thematic analysis, and drafted the initial manuscript. FR contributed to data validation, literature review refinement, and critical revisions of the manuscript. MF supervised the research process, provided theoretical guidance, and reviewed the final draft for academic rigor. All authors reviewed and approved the final version of the manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

Ethical Considerations

All sources have been appropriately cited to ensure proper credit to original authors and to avoid plagiarism. Since this article is a review of existing literature, no new data involving human or animal subjects were collected, thus exempting it from institutional ethical approval. The authors have maintained transparency by objectively discussing study findings, acknowledging limitations, and avoiding conflict of interest.

Funding/Support

This research received no specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Availability of Data and Materials

The datasets analyzed during this study are available from the corresponding author on reasonable request, subject to ethical and privacy considerations.

References

1 Saiz-González P, Sierra-Díaz J, Iglesias D, Fernandez-Rio J. Exploring physical education teachers' willingness and barriers to integrating digital technology in their lessons. Educ Inf Technol. 2024;1–23. doi: 10.1007/s10639-024-13060-9.
2 Krstić D, Vučković T, Dakić D, Ristić S, Stefanović D. The application and impact of artificial intelligence on sports performance improvement: A systematic literature review. In: The 4th International Conference on Communications, Information, Electronic and Energy Systems (CIEES). 2023 Nov 23; Plovdiv, Bulgaria. New York, USA: IEEE; 2023.

doi: 10.1109/CIEES58940.2023.10378750.
3 Vimalnath V, Karthick KK . Revolutionizing Physical Education: The Role of Artificial Intelligence in Enhancing Learning and Performance. Library Progress International. 2024;44(3):16486-94. doi: 10.48165/bapas.2024.44.2.1.
4 Bruno A, Guerriero M, Basta A, Moscatelli F. Artificial intelligence, a useful ally in physical education at school. Ital J Health Educ Sports Incl Didact. 2024;8(2). doi: 10.32043/gsd.v8i2.1198.
5 Wang Y, Wang X. Artificial intelligence in physical education: comprehensive review and future teacher training strategies. Front Public Health. 2024;12:1484848. doi: 10.3389/fpubh.2024.1484848. PubMed PMID: 39583072; PubMed Central PMCID: PMC11581949.
6 Xu J, Qi D, Liu S. Intelligent sports teaching tracking system based on multimedia data analysis and artificial intelligence. Tehnički vjesnik. 2024;31(3):951–958. doi: 10.17559/TV-20240123001285.
7 Wang C, Du C. Optimization of physical education and training system based on machine learning and Internet of Things. Neural Comput Appl. 2022;1–16. doi: 10.1007/s00521-021-06278-y.
8 Maněnová M, Knajfl P, Wolf J. Motivation and performance of students in school physical education in which mobile applications are used. Sustainability. 2022;14(15):9016. doi: 10.3390/su14159016.
9 Hu X, Li J. Research on the integrated solution of physical education based on smart campus. Adv Physiol Educ. 2024;48(2):378-384. doi: 10.1152/advan.00006.2024. PubMed PMID: 38420666.
10 Su Z, Ge S, Li LG, Su Y. Review study of integrating AI technology into sports training system. Educ Adm Theory Pract. 2024;30(5):7134–7140. doi: 10.53555/kuey.v30i5.1649.
11 Yu H, Wang J. Construction of a Big Data-based Student Performance Assessment and Personalised Instruction System in Physical Education Teaching. In: 2024 9th Int Symp Comput Inf Process Technol (ISCIPT). 2023 May 24-26; Xi' an, China. USA: IEEE; 2024. p. 167–71. doi: 10.1109/ISCIPT61983.2024.10673255.
12 Zhang J, Oh YJ, Lange P, Yu Z, Fukuoka Y. Artificial Intelligence Chatbot Behavior Change Model for Designing Artificial Intelligence Chatbots to Promote Physical Activity and a Healthy Diet: Viewpoint. J Med Internet Res. 2020;22(9):e22845. doi: 10.2196/22845. PubMed PMID: 32996892; PubMed Central PMCID: PMC7557439.
13 Naughton M, Salmon PM, Compton HR, McLean S. Challenges and opportunities of artificial intelligence implementation within sports science and sports medicine teams. Front Sports Act Living. 2024;6:1332427. doi: 10.3389/fspor.2024.1332427. PubMed PMID: 38832311; PubMed Central PMCID: PMC11144926.
14 Genç N. Artificial intelligence in physical education and sports: New horizons with ChatGPT. Akdeniz Spor Bilimleri Dergisi. 2023;6(1):17–32. doi: 10.38021/asbid.1291604.
15 Lee HS, Lee J. Applying artificial intelligence in physical education and future perspectives. Sustainability. 2021;13(1):351. doi: 10.3390/su13010351.
16 Zhao M, Lu X, Zhang Q, Zhao R, Wu B, Huang S, Li S. Effects of exergames on student physical education learning in the context of the artificial intelligence era: a meta-analysis. Sci Rep. 2024;14(1):7115. doi: 10.1038/s41598-024-57357-8. PubMed PMID: 38531948; PubMed Central PMCID: PMC10965939.
17 Sadr MM, Saheb T, Farahani A. A Mapping and Visualization of the Role of Artificial Intelligence in Sport Industry. Res Sport Manag Mark. 2023;5(1):44–56. doi: 10.22098/rsmm.2023.13064.1241.
18 Modra C, Domokos M, Petracovschi S. The use of digital technologies in the physical education lesson: A systematic analysis of scientific literature. Timişoara Phys Educ Rehabil J. 2021;14(26):33. doi: 10.2478/tperj-2021-0004.

19 Killian CM, Marttinen R, Howley D, Sargent J, Jones EM. "Knock, Knock… Who's there?" ChatGPT and artificial intelligence-powered large language models: reflections on potential impacts within health and physical education teacher education. J Teach Phys Educ. 2023;42(3):385–389. doi: 10.1123/jtpe.2023-0058.
20 Rosa JPP. The potential role of artificial intelligence to promote the participation and inclusion in physical exercise and sports for people with disabilities: A narrative review. J Bodyw Mov Ther. 2025;42:127-131. doi: 10.1016/j.jbmt.2024.12.024. PubMed PMID: 40325657.
21 Chrastina J. Meta-Synthesis of Qualitative Studies: Background, Methodology and Applications. NORDSCI Conference on Social Sciences. 2018 July 17-19; Helsinki, Finland. Sofia, Bulgaria: Saima Consult Ltd; 2018. doi: 10.32008/NORDSCI2018/B1/V1/13.
22 Walsh D, Downe S. Meta-synthesis method for qualitative research: a literature review. J Adv Nurs. 2005;50(2):204-11. doi: 10.1111/j.1365-2648.2005.03380.x. PubMed PMID: 15788085.
23 Thomas J, Harden A. Methods for the thematic synthesis of qualitative research in systematic reviews. BMC Med Res Methodol. 2008;8:45. doi: 10.1186/1471-2288-8-45. PubMed PMID: 18616818; PubMed Central PMCID: PMC2478656.
24 Cooke A, Smith D, Booth A. Beyond PICO: the SPIDER tool for qualitative evidence synthesis. Qual Health Res. 2012;22(10):1435-43. doi: 10.1177/1049732312452938. PubMed PMID: 22829486.
25 Zhou T, Wu X, Wang Y, Wang Y, Zhang S. Application of artificial intelligence in physical education: A systematic review. Educ Inf Technol. 2024;29(7):8203–8220. doi: 10.1007/s10639-023-12128-2.
26 Hong QN, Fàbregues S, Bartlett G, Boardman F, Cargo M, Dagenais P, et al. The Mixed Methods Appraisal Tool (MMAT) version 2018 for information professionals and researchers. Educ Inf. 2018;34(4):285–91. doi: 10.3233/EFI-180221.
27 Strauss A, Corbin J. Basics of qualitative research: Techniques and procedures for developing grounded theory. 2nd ed. Sage Publications. 1998.
28 Gabarron E, Larbi D, Rivera-Romero O, Denecke K. Human factors in AI-driven digital solutions for increasing physical activity: Scoping review. JMIR Hum Factors. 2024;11:e55964. doi: 10.2196/55964.
29 Mishra N, Habal BGM, Garcia PS, Garcia MB. Harnessing an AI-Driven Analytics Model to Optimize Training and Treatment in Physical Education for Sports Injury Prevention. In: Proc 2024 8th Int Conf Educ Multimedia Technol. 2024 June 22-24; Tokyo, Japan. New York: Association for Computing Machinery; 2024. P. 309-15. doi: 10.1145/3678726.3678740.
30 Dergaa I, Saad HB, El Omri A, Glenn J, Clark C, Washif J, et al. Using artificial intelligence for exercise prescription in personalised health promotion: A critical evaluation of OpenAI's GPT-4 model. Biol Sport. 2024. doi: 10.5114/biolsport.2024.133661. PubMed PMID: 38524814; PubMed Central PMCID: PMC10955739.
31 Kaswan KS, Dhatterwal JS, Ojha RP. AI in personalized learning. In: Adv Technol Innov Higher Educ. Boca Raton, Fla, US: CRC Press; 2024. p. 103–117. doi: 10.15354/sief.24.co346.
32 Rahmani M, Majedi N. Application of Artificial Intelligence in the Sports Industry: A Review Article. AI Tech Behav Soc Sci. 2024;2(2):20–27. doi: 10.61838/kman.aitech.2.2.4.
33 Almusawi HA, Durugbo CM, Bugawa AM. Innovation in physical education: Teachers' perspectives on readiness for wearable technology integration. Comput Educ. 2021;167:104185. doi: 10.1016/j.compedu.2021.104185.

34 Cudicio A, Sangalli S, Lucaccioni L, Borgogni A. Artificial intelligence in personalizing physical education: A two-year study. Ital J Health Educ Sport Incl Didact. 2024;8(2). doi: 10.32043/gsd.v8i2.1119.
35 Molavian R, Fatahi A, Abbasi H, Khezri D. Artificial Intelligence Approach in Biomechanics of Gait and Sport: A Systematic Literature Review. J Biomed Phys Eng. 2023;13(5):383-402. doi: 10.31661/jbpe.v0i0.2305-1621. PubMed PMID: 37868944; PubMed Central PMCID: PMC10589692.
36 Hsia LH, Hwang GJ, Hwang JP. AI-facilitated reflective practice in physical education: An auto-assessment and feedback approach. Interact Learn Environ. 2024;32(9):5267–5286. doi: 10.1080/10494820.2023.2212712.
37 Khanal SR, Paulino D, Sampaio J, Barroso J, Reis A, Filipe V. A review on computer vision technology for physical exercise monitoring. Algorithms. 2022;15(12):444. doi: 10.3390/a15120444.
38 Li D, Sun Y. Improvement of students' sports performance in VR-based smart sports teaching in colleges and universities. Appl Math Nonlinear Sci. 2024;9(1):1–13. doi: 10.2478/amns-2024-1373.
39 Cao F, Lei M, Lin S, Xiang M. Application of Artificial Intelligence-Based Big Data AI Technology in Physical Education Reform. Mobile Information Systems. 2022;2022(1):4017151. doi: 10.1155/2022/4017151.
40 Li N, Xue Y. Artificial Intelligence-Based Assessment of Physical Education and Training Effectiveness. Comput-Aided Des Appl. 2022;75–84. doi: 10.14733/cadaps.2023.S5.75-84.
41 Liu W. Sports motivation and sports success of college student-athletes in China. Int J Res Stud Educ. 2024;13(10):55–70. doi: 10.5861/ijrse.2024.24706.
42 Masters K. Ethical use of Artificial Intelligence in Health Professions Education: AMEE Guide No. 158. Med Teach. 2023;45(6):574-84. doi: 10.1080/0142159X.2023.2186203. PubMed PMID: 36912253.
43 Mokmin NAM. The effectiveness of a personalized virtual fitness trainer in teaching physical education by applying the artificial intelligent algorithm. Int J Human Mov Sports Sci. 2020;8(5):258–264. doi: 10.13189/saj.2020.080514.
44 Neji W, Boughattas N, Ziadi F. Exploring new AI-based technologies to enhance students' motivation. Issues Inform Sci Inf Technol. 2023;20:95–110. doi: 10.28945/5149.
45 Oh YJ, Zhang J, Fang ML, Fukuoka Y. A systematic review of artificial intelligence chatbots for promoting physical activity, healthy diet, and weight loss. Int J Behav Nutr Phys Act. 2021;18:160. doi: 10.1186/s12966-021-01224-6.
46 Reis FJJ, Alaiti RK, Vallio CS, Hespanhol L. Artificial intelligence and Machine Learning approaches in sports: Concepts, applications, challenges, and future perspectives. Braz J Phys Ther. 2024;28(3):101083. doi: 10.1016/j.bjpt.2024.101083. PubMed PMID: 38838418; PubMed Central PMCID: PMC11215955.
47 Su Z, Li L, Su Y. Transforming College Physical Education: Exploring the Integration of Artificial Intelligence Technology. Perform Health J. 2024;3(1):29–38. doi: 10.53797/fphj.v3i1.5.2024.
48 Tang X. Innovative Technology in Teaching: Enhancing Self-Learning Abilities Among Physical Education Majors. iJOINED ETCOR. 2024;3(2).
49 Tariq M, Sergio R. Innovative Assessment Techniques in Physical Education: Exploring Technology-Enhanced and Student-Centered Models for Holistic Student Development. Glob Innov Phys Educ Health. 2024;4:85–112. doi: 10.4018/979-8-3693-3952-7.ch004.
50 Tian J, Guo Z. Exploring the Role of AR in Physical Education: Challenges and Opportunities for Socialization. Int J Hum–Comput Interact. 2024;1–11. doi:

10.1080/10447318.2024.2434960.

51 An R, Shen J, Wang J, Yang Y. A scoping review of methodologies for applying artificial intelligence to physical activity interventions. J Sport Health Sci. 2024;13(3):428-441. doi: 10.1016/j.jshs.2023.09.010. PubMed PMID: 37777066; PubMed Central PMCID: PMC11116969.

52 Young L, O'Connor J, Alfrey L, Penney D. Assessing physical literacy in health and physical education. Curric Stud Health Phys Educ. 2021;12(2):156–179. doi: 10.1080/25742981.2020.1810582.