Globets

Available online at **globets.org/journal**
International Journal of Education, Technology and Science
6(3) (2026) 359–374

IJETS
International Journal of Education Technology and Science

THE APPLICATION OF INNOVATION, EMERGING TECHNOLOGIES, AND ARTIFICIAL INTELLIGENCE IN PHYSICAL EDUCATION INSTRUCTION: CHALLENGES AND OPPORTUNITIES AHEAD

(Review article)

Bisotoon Azizi [a] [1], Mohammad Mohammadi [b]

[a] *Department of Physical Education, Ur. C., Islamic Azad University, Urmia, Iran*
[b] *Department of Physical Education, Faculty of Literature and Humanities, Malayer University, Malayer, Iran*

Received: 09.03.2026 Revised version received: 19.06.2026 Accepted: 21.06.2026

Abstract

This systematic review and interpretive synthesis aimed to provide a comprehensive, evidence-based framework for the effective incorporation of emerging technologies and AI into physical education. The search was conducted in international and Persian databases, including PubMed, Scopus, Web of Science, SID and Noormags in order to identify studies published between 2015 up to 2024. The search process resulted in the identification of 1,283 records; after removal of the duplicated papers, title/abstract evaluation, and full-text evaluation of potential studies, 47 studies were selected for the current review (20 international studies and 27 Iranian studies). The quality of the studies included in the current review was evaluated using the Cochrane RoB 2, CASP and MMAT checklists. The technologies were categorized into three pedagogical levels: monitoring by means of wearable technologies, feedback provided through VR and video analysis, and somatization via AI-driven systems. While emerging technologies in physical education hold great promise for PE in terms of providing opportunities for personalization of instruction and increasing PE engagement, several barriers to adoption, including a number of ethical concerns (e.g. data privacy, algorithmic bias), the digital divide, and lack of preparation on the part of teachers to utilize technologies for teaching and learning physical education, need to be addressed. The current review drew attention to the strategic role of teachers in physical education and to the ways in which they can integrate emerging technologies into PE in order to realize physical education's educational goals. The current review also highlighted several important research gaps including the scarcity of long-term studies conducted in regular school settings and the lack of locally grounded teaching models. The technologies reviewed in this article are enablers and not substitutes for teachers in physical education; thus, these technologies must be creatively combined with the teacher's strategic role and within the framework of PE's educational goals with support from professional development, local knowledge production, and equitable policymaking.

Keywords: Physical education, educational technology, artificial intelligence, ethical challenges, digital divide, teacher professional development

[1]Corresponding author: Bisotoon Azizi. ORCID ID.: https://orcid.org/0000-0001-5300-4935
E-mail: bistonazizi@iau.ac.ir
DOI: https://doi.org/10.5281/zenodo.22212767

1. Introduction

Physical Education (PE) has long been recognized as a cornerstone in the development of a healthy, physically literate and socially capable generation. Historically, PE is learning through embodied practice in situations where teachers and students are directly engaged and receive feedback on their performance in real time (Kirk, 2013). However, over the last decade the accelerating pace of digital transformation has fundamentally altered many dimensions of human activity, including education, and has begun to challenge long-standing pedagogical paradigms. Emerging innovative technologies, especially Artificial Intelligence (AI), offer opportunities to personalize instruction, enhance motor learning and increase student engagement. Despite this potential, it is necessary to critically examine the possible role(s) of technology in a discipline fundamentally rooted in human movement and interpersonal connection (Casey & Jones, 2011; Jastrow et al., 2022; Sargent & Calderón, 2022).

The need to systematically examine technology integration in PE arises from three converging global trends relating to the amounts and forms of physical activity that children and young people engage in. Research has consistently shown that the majority of children and young people fail to meet the recommended levels of physical activity (Guthold et al., 2020). PE classes represent one of the few settings where universal access to movement education is possible. However, traditional instructional methods have proven insufficient to reverse these sedentary behaviors. Emerging technologies—particularly wearable monitors, active video games, and AI-driven motivational systems—offer novel behavioral change mechanisms that could complement existing pedagogical strategies (Au et al., 2024; Lubans et al., 2014; Moller et al., 2023). Without a rigorous evidence base, however, educators risk adopting expensive tools that deliver no measurable health benefit. Secondly, a global educational landscape is currently undergoing digital transformation, accelerated by the post-pandemic reality of hybrid and technology-mediated learning. Young people arrive in PE lessons with digital fluency that shapes their expectations of feedback, engagement, and personalization. How teachers of PE can align pedagogy with contemporary learner profiles without sacrificing the embodied, relational essence of the discipline, therefore currently is a major question. Thirdly, from a policy and equity perspective, the rapid proliferation of educational technologies has outpaced the development of ethical guidelines, teacher training frameworks, and infrastructure standards (Love et al., 2019; Regan & Jesse, 2019; Williamson & Eynon, 2020). Schools in affluent areas are increasingly adopting motion-capture systems, heart-rate monitors, and AI assessment tools, while under-resourced schools lag further behind. This digital divide threatens to transform technology from a force for democratizing education into a mechanism for exacerbating existing inequalities. Consequently, identifying context-sensitive, cost-effective, and ethically sound integration models is an ethical imperative. The present review addresses this by synthesizing evidence from both high-income and middle-income settings, including Iran.

A growing body of evidence has been produced on the topic of technology in PE but research is fragmented, lacks synthetic frameworks, and has several critical knowledge gaps that impede evidence-based practice (Jastrow et al., 2022; Sargent & Calderón, 2022). The central problem is how to integrate emerging technologies and AI into PE instruction such that they act not as substitutes for human interaction, but as enablers that support the realization of authentic educational objectives. This problem can be explored through four interrelated sub-questions that existing literature has inadequately addressed. Firstly, there is no consensus on a typology of technologies according to their pedagogical function; current research has been undertaken using different categories of technology such as monitoring devices, feedback systems and AI-driven personalization, but these categories are often treated in isolation. A unified typology of technologies according to their pedagogical function is required in order to enable teachers and researchers to share a language for selecting from available technologies those that are suitable for achieving particular learning outcomes. Secondly, currently available evidence on the use of technologies in PE has been disproportionately gathered in laboratory or elite sport contexts and therefore provides little insight into the effectiveness of technologies in typical school settings with typical class sizes, limited time, and heterogeneous student abilities. Thirdly, long-term sustained effects on skill development, fitness and affective outcomes of use of technologies in PE are almost entirely absent from longitudinal studies, with current research primarily recording short-term 'novelty' effects (Barnett et al., 2013). Fourthly, current models of integration of technologies into PE have largely treated a range of key ethical and equity considerations (data privacy, algorithmic bias, digital divide, teacher readiness) as secondary considerations rather than core components of integration models (Akgun & Greenhow, 2022; Holmes et al., 2022; Lupton & Williamson, 2017; Regan & Jesse, 2019; Williamson & Eynon, 2020). Furthermore, in Iran, there are specific barriers to use of technology in PE including unequal access to digital infrastructure, a shortage of locally produced content aligned with national curricula, and the absence of systematic teacher empowerment programs.

Answering the questions posed by this problem, rather than investigating whether or not technology works in PE in a success-story like manner, requires a systematic synthesis of the numerous studies undertaken into the use of technology in order to identify key patterns, gaps, and actionable principles. This set of more interrelated and nuanced questions, rather than simply that of technology in PE (i.e. does it work?), requires a review-based answer. The above set of questions differs from the simple question of technology in PE in that it requires not only an overview of what has been, but an analysis of what types of technologies are appropriate for which pedagogical purposes, an investigation into conditions (teacher training, infrastructure, class context) under which they produce measurable benefits, an exploration of unintended consequences, especially for vulnerable student populations, and how integration can be implemented equitably and ethically in diverse national contexts, including Iran.

Addressing this review question is not merely an academic exercise; it carries substantial practical urgency. Traditional, one-size-fits-all approaches to teaching physical education do not manage to accommodate the diversity of students' motor abilities, learning styles and motivational profiles. Furthermore, PE teachers often face severe time constraints and large class sizes, which limit delivery in a manner that can provide every student with individualized, corrective feedback. Technologies such as video analysis and wearable sensors can offer immediate, objective feedback, thereby complementing the teacher's limited capacity

(Mödinger et al., 2022; Zhou et al., 2021). Lastly, physical education is facing a problem with ‘disengagement’ among the current generation of students when physical activity is presented in traditional, non-technological formats. Innovative tools, if used judiciously, may help sustain their participation and foster long-term physical activity habits (Jastrow et al., 2022; Wallace et al., 2023).

A systematic examination of the existing literature reveals a clear evolutionary trajectory from simple monitoring devices to intelligent and adaptive systems. Early studies examined the effectiveness of simple monitoring devices, such as pedometers and accelerometers, for increasing physical activity awareness (Au et al., 2024; Lubans et al., 2014). Studies subsequently examined the use of two-dimensional video analysis software, which provided learners with visual feedback of their movements on screen, enabling them to compare their performance with that of models (Mödinger et al., 2022; O’Loughlin et al., 2013; Palao et al., 2015; Potdevin et al., 2018). After the introduction of the active video game consoles, researchers documented increased motivation and participation, particularly among sedentary children (Barnett et al., 2013; Liu et al., 2020; Moller et al., 2023). Recently, virtual reality systems have opened entirely new environments for skill practice and allow repetition and exploration in a controlled setting (Michalski et al., 2019; Neumann et al., 2018).

One further issue that can be related to the earlier described studies is the sustainable integration of PE technology into the daily school curriculum. Although long-term effects on children’s skill retention, fitness and affective outcomes remain unanswered, many of the previous studies only looked at short-term effects (i.e. over a few weeks or even months). More research is needed that looks at the longitudinal sustainable integration of PE technology into the daily school curriculum. Many previous technology-related studies have focused only on technological effectiveness in isolation and, therefore, lack important socio-emotional, ethical and pedagogical perspectives and insights needed for effective implementation in real-world educational settings, with issues of data privacy, algorithmic bias, and educational inequities rarely investigated together with efficacy outcomes (Akgun & Greenhow, 2022; Holmes et al., 2022; Lupton & Williamson, 2017; Regan & Jesse, 2019; Williamson & Eynon, 2020). Additional challenges for implementation, that are particularly salient in Iran, include a shortage of locally relevant educational content as well as the challenge that most educational technology is developed within a Western context and therefore may not align with Iranian curricula, cultural norms, or language. Moreover, teacher professional development programs aimed at technology integration are either absent or insufficiently focused on pedagogical application rather than mere technical operation, as most of the focus is on technical issues over pedagogical practice (Bodsworth & Goodyear, 2017; Wallace et al., 2023; Wyant & Baek, 2019).

The present study undertakes a systematic review with an interpretive synthesis approach. The purpose of the study was to present a comprehensive, practical and evidence-based framework for the responsible, equitable and effective integration of emerging technologies such as AI into general PE instruction. While many technologies for PE are available and presented with promises of their effectiveness, the question of what works and for whom, in what circumstances and at what potential ethical and practical costs remains. This study is meant to aid PE teachers and teacher educators, curriculum developers and policymakers. It also highlights the most pressing gaps in current knowledge, namely the need for longitudinal, school-based studies, as well as locally grounded teaching models. The findings of this study were synthesized from both international and Iranian studies published between 2015 and 2024. To achieve the above objectives, the present systematic review addresses the following explicit research questions:

1. How can emerging technologies and artificial intelligence in physical education instruction be classified based on their pedagogical function?
2. What are the main opportunities and challenges of integrating these technologies into physical education instruction at the global level and specifically in Iran?
3. What are the existing research gaps in the field of integrating emerging technologies and artificial intelligence into physical education instruction?
4. What practical, evidence-based framework can be proposed for the responsible, equitable, and effective integration of these technologies into physical education instruction?

2. Method

2.1. Research design

A systematic review was conducted using an interpretive synthesis approach to identify, compare and integrate recurring themes from the studies included in the review, enabling an in-depth understanding of how artificial intelligence has been applied in physical education. The review was reported in accordance with the PRISMA 2020 statement (Page et al., 2021). The review comprised a systematic search for literature, removal of duplicates, screening of studies against predefined eligibility criteria, full-text assessment, data extraction and thematic synthesis of the findings.

2.2. Sampling

A systematic search for relevant studies was performed in international databases (PubMed, Scopus, and Web of Science) and Persian databases (SID and Noormags). The studies were limited to English and Persian languages, and published between January 1, 2015, and December 31, 2024 (Gregorian), and Farvardin 1, 1395, to Esfand 29, 1403 (Persian calendar). The search strategy combined terms related to AI and digital technologies with terms related to physical education, school sport, motor learning, teachers, ethics and student data privacy. The Boolean operator “AND” was used to connect the principal concepts. The search terms were adjusted to suit the particular database’s indexes and search fields.

The English-language search used combinations of terms related to artificial intelligence and physical education, wearable technology and school sport, virtual reality and motor learning, the digital divide and physical education teachers, and AI ethics and student data privacy. Equivalent Persian terms were used to search SID and Noormags. The retrieved records were then combined, duplicates were removed, and the remaining articles were screened according to the predefined eligibility criteria. Eligible publications included quantitative, qualitative, and mixed-methods studies, as well as systematic reviews, theoretical papers, and intervention studies. Studies were required to examine the use of digital technologies, artificial intelligence, virtual or augmented reality, or wearable devices in physical education at the school or university level. Only publications written in English or Persian were considered. Studies focusing exclusively on elite sport without an instructional component were excluded. Publications were also excluded when an abstract or full text was unavailable or when they were rated as having low methodological quality using the selected appraisal tools. Letters to the editor, case reports, and non-peer-reviewed conference papers were not considered. After duplicates were removed using EndNote 21, two independent reviewers (first and second authors) screened the titles and abstracts of the potential studies. In the second stage, the full texts of the remaining articles were assessed. Any disagreements between the two reviewers were resolved through discussion or, if necessary, by consulting a third reviewer (the corresponding author). The number of articles at each stage of the review was recorded in a PRISMA flow diagram.

2.3. Quality Assessment

Quality assessment was performed by evaluating the studies by means of the appropriate design-related appraisal tools: for quantitative experimental studies, the revised Cochrane risk-of-bias tool for randomized trials (RoB 2; Sterne et al., 2019); for qualitative studies, the CASP Qualitative Checklist; and for mixed-methods studies, the Mixed Methods Appraisal Tool (MMAT) version 2018. Articles scoring below 60% of the corresponding criteria were excluded from the final analysis.

2.4. Data Analysis and Synthesis

Directed qualitative content analysis and interpretive synthesis were used. In the course of this analysis, initial codes were extracted, then these codes were grouped into meaningful categories and, finally, meta-analytic patterns were identified. To enhance trustworthiness, two independent analysts performed the coding process. The inter-coder agreement was measured by Kappa and reached 0.82. The data from the publications were extracted with the help of a pre-designed data extraction form that included: author(s), year of publication, country, research method, sample population, type of technology, key findings, limitations of the study and research gaps.

3. Findings

From a total of 1,283 retrieved articles, after removing duplicates (412 articles) and title/abstract screening (871 articles), 112 articles were selected for full-text assessment. Ultimately, 47 articles met the inclusion criteria and were entered into the final analysis (20 international, 27 domestic).

3.1. Levels and Types of Technology Use

Based on content analysis, the technologies used were classified into three levels (Table 1):

Table 1. Levels of Technology Use in Physical Education Instruction

Level	Category	Examples	Key Findings
First	Monitoring & Measurement	Activity trackers, heart rate monitors	Increased physiological self-awareness and motivation (Au et al., 2024; Lubans et al., 2014)
Second	Feedback & Movement Correction	Video analysis, VR, AR	Facilitates learning of complex skills alongside the teacher (Mödinger et al., 2022; O'Loughlin et al., 2013; Potdevin et al., 2018)
Third	Smart & Personalized	Computer vision, AI, chatbots	Potential for automated feedback and hyper-personalized planning (Akgun & Greenhow, 2022; Jastrow et al., 2022)

3.2. Analysis of Effectiveness and Outcomes

Most studies reported increased student participation, intrinsic motivation and student engagement as primary outcomes. Active video games (Barnett et al., 2013; Liu et al., 2020; Moller et al., 2023) and virtual reality environments (Michalski et al., 2019; Neumann et al., 2018) were powerful drivers in this regard. However, no strong evidence was found for a sustained, direct impact on cardiorespiratory fitness over the long term.

Key finding: The greatest effectiveness of technology in physical education was observed when it was used as a complement to the teacher. Technology can provide objective feedback, while the teacher interprets this data, guides learning strategies, and deepens the pedagogical relationship (Bodsworth & Goodyear, 2017; Kirk, 2013; Sargent & Calderón, 2022).

3.3. Identified Challenges and Barriers

Challenges were classified into two main categories (Table 2):

Table 2. Main Challenges to Technology Integration

Level	Type of Challenge	Examples
Global	Ethical and governance	Privacy of biometric data, algorithm transparency, algorithmic bias (Holmes et al., 2022; Regan & Jesse, 2019; Williamson & Eynon, 2020)
Iran	Infrastructural and institutional	Inequality of access, lack of local content, absence of teacher empowerment programs

3.4. Key Research Gaps

The present systematic review identified four major gaps:

1. A lack of longitudinal research assessing the long-term effects of technology on multidimensional outcomes (skill, health, affective).
2. A scarcity of studies in real-world settings; most research has been conducted in laboratory conditions or with elite athletes.
3. Neglect of the design of integrated teaching models that guide teachers in selecting and adapting technology to specific curricular objectives.
4. A shortage of local research in Iran to produce actionable knowledge that is compatible with the existing culture and resources.

4. Discussion and Conclusion

This review looked at the findings of 47 studies on emerging technologies in PE (including 20 international studies and 27 Iranian studies). A key point emerging from the review is that technology can be a powerful amplifier of pedagogical practice and should never be used as a substitute for the skilled human educator (Casey & Jones, 2011; Jastrow et al., 2022; Kirk, 2013; Sargent & Calderón, 2022). Thus, while review findings detailed numerous PE technologies (and their applications in monitoring, feedback, and smart systems) reviewed here, the path forward must be guided by pedagogical wisdom, not by technological novelty alone (Casey & Jones, 2011; Jastrow et al., 2022; Kirk, 2013; Sargent & Calderón, 2022).

4.1. Technology as an Enabler, not a Substitute

The findings from studies which focused on technology implemented within the monitoring, feedback and smart systems levels of PE found that the most successful implementations were those which positioned the teacher at the centre of the learning process. Wearable technology such as heart-rate monitors and activity trackers increased students' physiological self-awareness, however translating this awareness into behaviour change was more effective when teachers helped students to interpret data and set meaningful personal goals (Au et al., 2024; Lubans et al., 2014). Video analysis and virtual reality systems provided students with rich visual feedback that enhanced motor learning, yet learning gains were maximized when teachers facilitated students' reflection on feedback, asked probing questions, and helped students connect the feedback to broader movement principles (Mödinger et al., 2022; Neumann et al., 2018; O'Loughlin et al., 2013; Palao et al., 2015; Potdevin et al., 2018; Zhou et al., 2021). Emerging AI-driven systems, including computer vision for movement assessment and chatbots for personalized PE instruction, function best as decision-support tools that augmented rather than supplanted the teacher's judgment (Holmes et al., 2022; Sargent & Calderón, 2022; Zawacki-Richter et al., 2019). This finding aligns with Kirk's (2013) argument that the intrinsic educational value of PE resides in human interaction—in the moment-to-moment adjustments, the encouragement, the shared struggle, and the celebration of effort. Technology can measure, record and even predict, but it cannot empathize, inspire, or build the kind of trusting relationship that lies at the heart of meaningful PE. Therefore, any integration framework that prioritizes technological efficiency over relational quality will fail, regardless of the sophistication of the technologies used.

4.2. Personalization and Engagement: The Promise and Its Limits

Studies on technology in physical education report that active video games, virtual reality programs and AI-driven adaptive learning platforms captured the attention of students with low baseline motivation, or who feel marginalized in traditional PE settings (Barnett et al., 2013; Liu et al., 2020; Moller et al., 2023; Wallace et al., 2023). Technologies that offer students choices in physical activities, instant feedback and a low-threat environment for practice represent genuine progress in meeting the needs of a diverse student population. However, while engagement often increased in the short term, evidence for sustained improvements in long-term physical activity behavior or cardiorespiratory fitness was surprisingly weak (Au et al., 2024; Love et al., 2019; Moller et al., 2023). Most of the studies reviewed measured outcomes over weeks or months and few followed students beyond the intervention period (Barnett et al., 2013; Liu et al., 2020; Moller et al., 2023; Wallace et al., 2023). That physical education can be more entertaining does not necessarily mean that physical education is being made more educative. There is a marked difference between physical education that is merely entertaining and physical education that equips students with the knowledge, skills, and dispositions to lead physically active lives long after they leave school (Kirk, 2013). Hence, future studies on the use of technology in physical education should look beyond increased participation in physical education and examine whether technology-enhanced PE produces lasting changes in physical activity habits, health literacy and intrinsic motivation for lifelong movement.

4.3. Ethical Challenges and the Problem of Algorithmic Bias

These studies examined current practice of school-based PE utilizing AI for movement analysis, fitness assessment and even injury prediction. Ethical considerations can no longer be treated as an afterthought, particularly in studies from international contexts (Akgun & Greenhow, 2022; Holmes et al., 2022; Lupton & Williamson, 2017; Regan & Jesse, 2019; Williamson & Eynon, 2020). Three interlocking concerns were revealed: (1) data privacy, (2) algorithm transparency, and (3) algorithmic bias. Biometric data collected by wearables—heart rate, movement patterns, even emotional states inferred from accelerometry—are among the most sensitive forms of personal information (Lupton & Williamson, 2017; Regan & Jesse, 2019). Yet many school-based implementations operate under vague or non-existent data governance policies. Students and parents often do not know what data are collected, who has access to them, how long they are retained, or whether they are shared with third parties. Algorithmic bias presents an even more insidious challenge (Akgun & Greenhow, 2022; Holmes et al., 2022). Most AI systems are trained on datasets that over-represent certain populations—often male, often athletic, often from specific ethnic or socioeconomic backgrounds. When such systems are deployed in diverse school settings, they may systematically misassess students who fall outside the training distribution. For example, a computer vision system trained primarily on male athletes performing a squat or a plank may penalize female students for movement patterns that are biomechanically normal for them but deviate from the 'ideal' derived from the training data. Similarly, an AI coaching assistant might provide more encouraging feedback to students whose movement styles resemble those of elite athletes, while subtly discouraging others. These biases are rarely intentional, but they are no less harmful. Developing ethical frameworks for the design, procurement and use of AI in PE is therefore an urgent priority—one that requires input not only from technologists but also from educators, ethicists, and communities.

4.4. The Digital Divide and the Iranian Context

One of the biggest barriers to the implementation of PE technology in Iran, as in many other countries, is inequitable access to digital infrastructure (Love et al., 2019; Regan & Jesse, 2019; Williamson & Eynon, 2020). The digital divide threatens to transform technology from a tool of equity into a mechanism for widening existing gaps. For those students who are already disadvantaged by having fewer resources outside of school (e.g. less access to sports facilities, less support for physical activity from parents), inferior technology-enriched instruction inside school could provide a further, double disadvantage. Therefore, a deliberate focus on low-cost, low-tech and offline-capable PE technology interventions (Wyant & Baek, 2019) is important. Simple interventions such as using mobile phones to complete peer video analysis, using free apps to monitor physical activity, and using QR codes to access instructional videos can be highly effective when paired with thoughtful pedagogy. Building foundational digital literacy among teachers and students and making sure all schools have basic digital infrastructure (reliable electricity, a projection screen, adequate bandwidth) are key priorities. Expensive hardware should be seen as a supplement, not a prerequisite.

4.5. Teacher Professional Development as the Critical Lever

Technology integration succeeds or fails based on the teacher (Bodsworth & Goodyear, 2017; Sargent & Calderón, 2022; Wallace et al., 2023; Wyant & Baek, 2019). Even the best hardware and software cannot compensate for a teacher who lacks confidence, knowledge, or pedagogical imagination to use technology purposefully. Conversely, a skilled teacher with limited resources can often achieve more than a poorly prepared teacher with the best tools (Bodsworth & Goodyear, 2017; Casey & Jones, 2011; Kirk, 2013; Wallace et al., 2023; Wyant & Baek, 2019). As is the case for many aspects of educational practice and teacher education, preparing teachers to utilize technology for physical education receives very little pre-service training and in-service professional development (Wallace et al., 2023; Wyant & Baek, 2019). Most professional development related to technology is a one-off workshop that focuses on technical operation—how to log in and generate reports—rather than how technology can be used to enhance pedagogical integration. Physical education teachers need a decision-making framework for when to use technology and when to put it away, and for aligning technological choices with specific learning objectives (Bodsworth & Goodyear, 2017). The framework should also assist teachers in interpreting data without losing sight of the whole child. The framework should also aid in creating a human-centered environment even as screens and sensors multiply. The most promising models of professional development are those that are sustained, collaborative, and embedded in teachers' current practices (Bodsworth & Goodyear, 2017). Thus, in contrast to one-off workshops on technology for physical education, the best professional development is ongoing and collaborative. Examples include professional learning communities, lesson study groups, coaching cycles, and opportunities to experiment with technology in low-stakes settings before scaling up. In Iran, where many teachers express anxiety about their digital competence, building teachers' confidence in utilizing technology for physical education is as important as teachers' acquisition of skill. Therefore, a gradual and supportive approach to training teachers, beginning with simple applications (e.g., video recording, mobile apps) and gradually moving towards more complex systems as comfort grows, is likely to be far more effective than a sudden, top-down mandate to adopt AI.

4.6. Future Research Directions

For future research to build on currently available knowledge, there is a need for (1) long-term studies spanning years with skill development and fitness as well as affective variables (e.g. enjoyment, self-efficacy, physical activity identity) being assessed in order to find out whether technology-based PE programs have a lasting effect on how children and young people relate to their bodies and to movement or whether the effects fade once the novelty wears off (Au et al., 2024; Jastrow et al., 2022; Moller et al., 2023); (2) more real-world studies conducted at schools rather than in the laboratory with consideration of the specific conditions in PE classes (e.g. time available for lessons, class size, students' diverse needs, inadequate infrastructure) which differ considerably from those found in laboratory experiments (Michalski et al., 2019; Mödinger et al., 2022); and participatory design studies, in which teachers and their students co-develop technology-based lessons for PE together. Building on currently available knowledge, future research is also needed to find out for whom a particular intervention is effective and under which circumstances. Therefore, studies should preferably report on effects for different subgroups of students (girls/boys, socioeconomic status, students who are physically active vs. those who are not, students with and without special educational needs) in order to identify which students might benefit most from technology-based PE and which students might be left behind or even harmed (Love et al., 2019). As for Iran, most of the existing knowledge base comes from Western contexts with different curricula, different infrastructure, and different cultural attitudes towards physical activity and digital technology. More locally grounded studies are, therefore, needed to find out how PE can be enhanced with the help of low-cost, readily available technology (e.g. mobile phones, free apps, social media) in resource-constrained settings and how the specific ethical concerns (e.g. issues of modesty, data privacy) encountered within the Iranian educational system can be addressed in a culturally appropriate manner.

4.7. Practical Pathways Forward

Actioning the findings of this review requires coordinated efforts at multiple levels. At the school level, teachers and administrators should start small (Bodsworth & Goodyear, 2017; Sargent & Calderón, 2022; Wyant & Baek, 2019): choose one or two low-cost technologies, integrate them into a single unit of instruction, document what happens, and learn from the process. This can start simply by having students video-record each other performing throwing actions and then analyzing the recordings in small groups. There is no need to rush towards AI-powered motion analysis. At the district and provincial levels, policymakers should prioritize basic digital infrastructure such as reliable internet, projection equipment, and a safe system for storing student data, before investing in flashy but expensive hardware. They should also establish clear ethical guidelines for data collection and use, informed by input from parents, students and teachers. At the national level, investments in teacher professional development should be substantially increased. Pre-service teacher education programs should include coursework on educational technology for PE, and in-service programs should move beyond one-off workshops toward sustained, practice-based learning opportunities (Wallace et al., 2023). A national online repository of teacher-created resources—lesson plans, instructional videos and assessment rubrics—would help disseminate effective practices and reduce the burden on individual teachers to reinvent the wheel.

4.8. Final Reflections

PE stands at a crossroads. Many technologies including wearables, virtual reality, computer vision, and AI-driven coaching are available. Used wisely, they can personalize instruction, deepen engagement, provide rich feedback, and help teachers see their students more clearly. Used poorly, they can distract from what matters, widen inequities, invade privacy, and reduce rich pedagogical encounters to sterile data streams (Akgun & Greenhow, 2022; Holmes et al., 2022; Lupton & Williamson, 2017; Regan & Jesse, 2019; Williamson & Eynon, 2020). The difference between these two futures depends not on the technology itself, but on the values and decisions of the people who implement it. A human-centered approach—one that places the learner and the pedagogical relationship at the center, that treats technology as a tool in service of broader educational goals, that attends to ethics and equity as first-order concerns—can harness the power of digital innovation without sacrificing the soul of PE. This is not a technophobic position, nor a techno-utopian one. It is a realistic, grounded, and ultimately hopeful vision: that by blending the best of tradition with the best of innovation, we can create PE that is more effective, more engaging, and more just than anything we have known before. The research reviewed here suggests that this vision is achievable. But it will not happen by accident. It will require deliberate effort, collective learning, and unwavering commitment to the students and teachers who inhabit the gymnasium every day.

5. Conclusion and Suggestions

The findings of this systematic review demonstrate that emerging technologies and artificial intelligence function solely as enabling tools and can never replace the central role of the teacher in PE. The most successful implementations occurred when the teacher remained at the heart of the teaching-learning process, with technology serving as a supportive aid for interpreting data, guiding learning strategies, and deepening pedagogical relationships. While capabilities such as real-time feedback, personalization, and short-term increased participation represent major opportunities afforded by technology, there is no strong evidence for a sustained impact on cardiorespiratory fitness or long-term changes in physical activity habits (Au et al., 2024; Love et al., 2019; Moller et al., 2023). On the other hand, serious challenges—including biometric data privacy, algorithmic bias, the digital divide, and the absence of teacher empowerment programs—were identified as primary barriers (Akgun & Greenhow, 2022; Holmes et al., 2022; Lupton & Williamson, 2017; Regan & Jesse, 2019; Wallace et al., 2023). In the Iranian context, unequal access to infrastructure and a lack of locally relevant content exacerbate these challenges. Clear research gaps include a scarcity of longitudinal studies in real-world school settings, neglect in designing integrated teaching models, and a shortage of actionable local research. The ultimate conclusion is that a desirable future for PE depends not on accumulating advanced hardware, but on a balanced integration of technological innovation and the pedagogical wisdom of the teacher. The path forward requires investment in teacher professional development, production of local knowledge, and equitable policymaking to ensure that technology does not perpetuate existing inequalities.

Based on the findings, the following suggestions can be put forward:

1. Schools should begin with simple, low-cost technologies such as mobile phone video recording and free applications, gradually progressing towards more complex systems.
2. Teacher empowerment programs must be continuous, collaborative, and practice-based, focusing on pedagogical decision-making rather than mere technical skills.
3. Policymakers should prioritize basic infrastructure—reliable internet and secure data storage—to reduce the digital divide before investing in expensive hardware.
4. Clear ethical frameworks for collecting and using students' biometric data should be developed with input from parents and teachers.
5. Researchers should conduct longitudinal studies in authentic school settings and context-specific local research to design teaching models compatible with Iran's culture and resources.

6. Research Limitations

There are a number of limitations inherent to this systematic review. Firstly, the review is dependent upon the quality, scope, and availability of the primary studies included. Any biases or methodological weaknesses within the studies included within this review have been reflected within this review's synthesis. Furthermore, the time frame of the review (2015–2024) may have excluded very recent technological developments or studies published after the date of the search. Additionally, despite best efforts to access full versions of studies, some articles—particularly from Persian databases—were not available in their entirety, which may have introduced a selection bias. The review is primarily based upon quantitative studies with few in-depth qualitative studies. Thus, the lived experiences, perceptions, and contextual nuances of teachers and students are not captured in full. In addition, because of the great variety of studies (research settings, populations, and interventions) included in this review, the findings of this review have limited direct generalizability to all educational and cultural contexts. Finally, the interpretive synthesis approach inevitably involves a degree of researcher subjectivity when coding and when developing themes. In order to mitigate this, the coding process was performed by two independent coders, and the inter-coder agreement was calculated (Kappa = 0.82). Although this review has limitations, it can provide a robust and valuable synthesis that can inform both practice and future research.

AI Use Statement

The authors declare their full responsibility for the theoretical development, content and originality of the manuscript. AI was solely used to improve the language fluency and grammatical accuracy.

Declaration of Conflicting Interests and Ethics

The author declares no conflict of interest. Ethical approval was not required because in this study did not involve any human participants or animal subjects.

References

Akgun, S., & Greenhow, C. (2022). Artificial intelligence in education: Addressing ethical challenges in K–12 settings. *AI and Ethics, 2*, 431–440. https://doi.org/10.1007/s43681-021-00096-7

Au, W. W., Recchia, F., Fong, D. Y., Wong, S. H., Chan, D. K. C., Capio, C. M., Yu, C. C. W., Wong, S. W. S., Sit, C. H. P., Ip, P., Chen, Y.-J., Thompson, W. R., & Siu, P. M. (2024). Effect of wearable activity trackers on physical activity in children and adolescents: A systematic review and meta-analysis. *The Lancet Digital Health, 6*(9), e625–e639. https://doi.org/10.1016/S2589-7500(24)00139-0

Barnett, L. M., Bangay, S., McKenzie, S., & Ridgers, N. D. (2013). Active gaming as a mechanism to promote physical activity and fundamental movement skill in children. *Frontiers in Public Health, 1*, Article 74. https://doi.org/10.3389/fpubh.2013.00074

Bodsworth, H., & Goodyear, V. A. (2017). Barriers and facilitators to using digital technologies in the Cooperative Learning model in physical education. *Physical Education and Sport Pedagogy, 22*(6), 563–579. https://doi.org/10.1080/17408989.2017.1294672

Casey, A., & Jones, B. (2011). Using digital technology to enhance student engagement in physical education. *Asia-Pacific Journal of Health, Sport and Physical Education, 2*(2), 51–66. https://doi.org/10.1080/18377122.2011.9730351

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2020). Global trends in insufficient physical activity among adolescents: A pooled analysis of 298 population-based surveys with 1.6 million participants. *The Lancet Child & Adolescent Health*, *4*(1), 23–35. https://doi.org/10.1016/S2352-4642(19)30323-2

Holmes, W., Porayska-Pomsta, K., Holstein, K., Sutherland, E., Baker, T., Shum, S. B., Santos, O. C., Rodrigo, M. T., Cukurova, M., Bittencourt, I. I., & Koedinger, K. R. (2022). Ethics of AI in education: Towards a community-wide framework. *International Journal of Artificial Intelligence in Education, 32*, 504–526. https://doi.org/10.1007/s40593-021-00239-1

Jastrow, F., Greve, S., Thumel, M., Diekhoff, H., & Süßenbach, J. (2022). Digital technology in physical education: A systematic review of research from 2009 to 2020. *German Journal of Exercise and Sport Research, 52*, 504–528. https://doi.org/10.1007/s12662-022-00848-5

Kirk, D. (2013). Educational value and models-based practice in physical education. *Educational Philosophy and Theory, 45*(9), 973–986. https://doi.org/10.1080/00131857.2013.785352

Liu, W., Zeng, N., McDonough, D. J., & Gao, Z. (2020). Effect of active video games on healthy children's fundamental motor skills and physical fitness: A systematic review. *International Journal of Environmental Research and Public Health, 17*(21), Article 8264. https://doi.org/10.3390/ijerph17218264

Love, R., Adams, J., & van Sluijs, E. M. F. (2019). Are school-based physical activity interventions effective and equitable? A meta-analysis of cluster randomized controlled trials with accelerometer-assessed activity. *Obesity Reviews, 20*(6), 859–870. https://doi.org/10.1111/obr.12823

Lubans, D. R., Smith, J. J., Skinner, G., & Morgan, P. J. (2014). Development and implementation of a smartphone application to promote physical activity and reduce screen-time in adolescent boys. *Frontiers in Public Health, 2*, Article 42. https://doi.org/10.3389/fpubh.2014.00042

Lupton, D., & Williamson, B. (2017). The datafied child: The dataveillance of children and implications for their rights. *New Media & Society, 19*(5), 780–794. https://doi.org/10.1177/1461444816686328

Michalski, S. C., Szpak, A., & Loetscher, T. (2019). Using virtual environments to improve real-world motor skills in sports: A systematic review. *Frontiers in Psychology, 10*, Article 2159. https://doi.org/10.3389/fpsyg.2019.02159

Mödinger, M., Woll, A., & Wagner, I. (2022). Video-based visual feedback to enhance motor learning in physical education: A systematic review. *German Journal of Exercise and Sport Research, 52*, 447–460. https://doi.org/10.1007/s12662-021-00782-y

Moller, A. C., Sousa, C. V., Lee, K. J., Alon, D., & Lu, A. S. (2023). Active video game interventions targeting physical activity behaviors: Systematic review and meta-analysis. *Journal of Medical Internet Research, 25*, Article e45243. https://doi.org/10.2196/45243

Neumann, D. L., Moffitt, R. L., Thomas, P. R., Loveday, K., Watling, D. P., Lombard, C. L., Antonova, S., & Tremeer, M. A. (2018). A systematic review of the application of interactive virtual reality to sport. *Virtual Reality, 22*(3), 183–198. https://doi.org/10.1007/s10055-017-0320-5

O'Loughlin, J., Ní Chróinín, D., & O'Grady, D. (2013). Digital video: The impact on children's learning experiences in primary physical education. *European Physical Education Review, 19*(2), 165–182. https://doi.org/10.1177/1356336X13486050

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., . . . Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ, 372*, n71. https://doi.org/10.1136/bmj.n71

Palao, J. M., Hastie, P. A., Cruz, P. G., & Ortega, E. (2015). The impact of video technology on student performance in physical education. *Technology, Pedagogy and Education, 24*(1), 51–63. https://doi.org/10.1080/1475939X.2013.813404

Potdevin, F., Vors, O., Huchez, A., Lamour, M., Davids, K., & Schnitzler, C. (2018). How can video feedback be used in physical education to support novice learning in gymnastics? Effects on motor learning, self-assessment and motivation. *Physical Education and Sport Pedagogy*, *23*(6), 559–574. https://doi.org/10.1080/17408989.2018.1485138

Regan, P. M., & Jesse, J. (2019). Ethical challenges of edtech, big data and personalized learning: Twenty-first century student sorting and tracking. *Ethics and Information Technology*, *21*(3), 167–179. https://doi.org/10.1007/s10676-018-9492-2

Sargent, J., & Calderón, A. (2022). Technology-enhanced learning physical education? A critical review of the literature. *Journal of Teaching in Physical Education, 41*(4), 689–709. https://doi.org/10.1123/jtpe.2021-0136

Sterne, J. A. C., Savović, J., Page, M. J., Elbers, R. G., Blencowe, N. S., Boutron, I., Cates, C. J., Cheng, H.-Y., Corbett, M. S., Eldridge, S. M., Emberson, J. R., Hernán, M. A., Hopewell, S., Hróbjartsson, A., Junqueira, D. R., Jüni, P., Kirkham, J. J., Lasserson, T., Li, T., . . . Higgins, J. P. T. (2019). RoB 2: A revised tool for assessing risk of bias in randomised trials. *BMJ*, *366*, l4898. https://doi.org/10.1136/bmj.l4898

Wallace, J., Scanlon, D., & Calderón, A. (2023). Digital technology and teacher digital competency in physical education: A holistic view of teacher and student perspectives. *Curriculum Studies in Health and Physical Education, 14*(3), 271–287. https://doi.org/10.1080/25742981.2022.2106881

Williamson, B., & Eynon, R. (2020). Historical threads, missing links, and future directions in AI in education. *Learning, Media and Technology, 45*(3), 223–235. https://doi.org/10.1080/17439884.2020.1798995

Wyant, J., & Baek, J.-H. (2019). Re-thinking technology adoption in physical education. *Curriculum Studies in Health and Physical Education, 10*(1), 3–17. https://doi.org/10.1080/25742981.2018.1514983

Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education: Where are the educators? *International Journal of Educational Technology in Higher Education, 16*, Article 39. https://doi.org/10.1186/s41239-019-0171-0