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Systematic Review

Embedding Digital Technologies (AI and ICT) into Physical Education: A Systematic Review of Innovations, Pedagogical Impact, and Challenges

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Abstract

This systematic review investigates the integration of artificial intelligence (AI) and information and communication technologies (ICT) in physical education across all educational levels. Physical education is uniquely centered on motor skill development, physical activity engagement, and health promotion—outcomes that require tailored technological approaches. Through the analysis of recent empirical studies, the main areas where digital technologies contribute to pedagogical innovation are highlighted—such as personalized learning, real-time feedback, student motivation, and educational inclusion. The findings show that AI-assisted tools facilitate differentiated instruction and self-regulated learning by adapting to students' individual performance levels. Technologies such as wearables and augmented reality (AR)/virtual reality (VR) systems increase engagement and support the participation of students with special educational needs. Furthermore, AI contributes to more efficient and objective assessment of motor performance, coordination, and movement quality. However, significant structural and ethical challenges persist, such as unequal access to digital infrastructure, lack of teacher training, and concerns related to personal data protection. Teachers' perceptions reflect both openness to the educational potential of AI and caution regarding its practical implementation. The review concludes that AI and ICT can substantially transform physical education, provided that coherent policies, clear ethical frameworks, and investments in teachers' professional development are in place.

Keywords: artificial intelligence; information and communication technologies; physical education; personalized learning; educational inclusion

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1. Introduction

The consideration of digital technologies in education has experienced accelerated development over the past 20 years, and physical education has been no exception to this trend. However, physical education presents unique pedagogical outcomes—where the main objective remains the stimulation of motor activity, coordination, and physical health, as also underlined by Aston (2018) [1] in the OECD study on children's physical health and well-being. In this sense, digitalization policies promoted by the European

Union and UNESCO aim to include technology in the educational process in a balanced and sustainable manner [2,3]. Tools based on artificial intelligence (AI) and information and communication technologies (ICT)—such as wearable motion sensors (e.g., IMU sensors, smartwatches), AI-based video analysis software (e.g., OpenPose, Dartfish), and interactive feedback systems—have been increasingly used to transform and optimize traditional, domain-specific teaching and learning methods. Mobile applications (e.g., Strava, MyFitnessPal, Fitbod) that monitor physical activity offer real-time feedback and engagement; these technologies have opened new perspectives for improving educational processes in physical education [4–6].

Within this thematic context, the literature identifies a key factor influencing this modern trend: teacher competencies. Prat Ambrós et al. [7], Tearle and Golder (2008) [8], and Bianchi et al. (2008) [9] note a strong openness among educators to adopting various types of ICT, while also emphasizing gaps in domain-specific digital training and the availability of resources. Additionally, Cojocaru et al. (2022) [10] show that e-learning, virtual reality, and related applications at two Romanian universities are creating flexible new learning spaces in physical education. Meanwhile, Díaz Barahona et al. (2020) [11] identify a connection between teachers' digital knowledge and their willingness to use ICT, noting that these aspects are influenced by significant inequalities related to equitable access to opportunities based on gender, age, and infrastructure [9,12].

The central findings of these studies emphasize the relevant impact of integrating information and communication technologies (ICT) in education. When ICT is used appropriately, it encourages students' active and conscious participation in teaching activities, supports knowledge consolidation and the development of digital skills, and thus creates a more stimulating formal learning environment that aligns with current socio-educational contexts. At the same time, these studies reveal persistent challenges, including inadequate teacher training, unequal access to digital resources, and difficulty in systematically incorporating new technological tools into pedagogical practice. These issues represent real barriers to educational modernization, aspects also confirmed by other studies [13,14].

Moreover, the wide variety of application strategies—such as gamification, hybrid methods, and distance learning—points to a significant reconfiguration of the traditional paradigm in physical education. These pedagogical directions clearly indicate a shift toward flexibility, individualization, and alignment with the nature of current digital environments. Current studies [15,16] reinforce the idea that technology in education must be based on coherent strategies based on teacher training and infrastructure development. Furthermore, all these studies suggest that ICT promotes an interesting transition from conventional physical education to a digitally enriched version—provided that all stakeholders are properly trained and resources are equitably distributed.

Few systematic reviews have addressed this topic in depth [17,18], especially distinguishing AI from ICT across the 2014–2025 period. This lack of synthesis hinders a comprehensive understanding of how these technologies can transform teaching, learning, and motor assessment in diverse educational contexts—from primary to higher education. Recent international literature includes many applied studies [19–21], but these differ significantly in methodology, target population, and objectives.

Considering these aspects, for the physical education lessons, a necessary analysis should focus on illustrating recurring patterns, developing trends, as well as common and specific challenges related to the implementation of information and communication technologies (ICT) and artificial intelligence (AI), respectively. This gap is especially relevant in the post-pandemic context, where schools have undergone an accelerated digitalization process, and physical education risks falling behind without informed and sustained interventions. A conceptual and empirical framework is needed to guide policy and pedagogical decisions regarding the equitable, safe, and effective use of technology in motor activities.

Most existing research consists of either case studies or contextual analyses, and the findings are often difficult to compare due to methodological diversity. In addition, many recent studies [22,23] focus on the general technological benefits in education without sufficiently detailing the bodily, motor, and relational specificities of physical education—elements that are essential when analyzing the integration of technology in this domain.

Thus, a synthesis of the aforementioned research suggests that integrating AI and ICT in physical education offers distinct advantages, such as enabling personalized learning approaches [4], providing real-time biomechanical feedback for rapid movement correction [6], and significantly improving student engagement through gamified and immersive experiences (e.g., VR/AR) [10,13]. These technologies have the potential to improve motor coordination, self-efficacy, and inclusive participation [7,9]. However, this perspective is not without potential drawbacks. These include an overreliance on technology, which may diminish traditional teacher–student interactions [8], risks of data privacy breaches [11], and exacerbating existing digital divides due to unequal access to resources and infrastructure [9,12]. Therefore, a critical and balanced approach is needed to maximize the benefits while mitigating these risks [5,14].

This paper addresses the existing gaps through a rigorous systematic analysis that classifies AI and ICT applications according to the targeted pedagogical domains. It critically evaluates both the transformative potential of these technologies and the structural and cultural barriers that limit their implementation. Thus, the study aims not only to provide a descriptive mapping but also to offer a critical reflection on the conditions that enable technology-assisted physical education while respecting the principles of equity, inclusion, and educational quality.

This systematic review seeks to highlight the main technological innovations used in physical education in recent years, to analyze their impact on teaching–learning processes, assessment, and inclusion, and to identify the challenges that hinder the effective application of these tools in formal educational settings—specifically in schools and universities. Another key objective is to illustrate both the educational benefits and the practical and ethical limitations that may disrupt or obstruct the use of technology in physical education lessons.

Through this analysis, the study aims to provide a comprehensive overview of the field's evolution, outlining the main research and development directions necessary to foster an intelligent physical education that is responsive to students' diverse needs and capable of maximizing the benefits of new technologies. Based on this analysis, future lines of research and development will be proposed to maximize the potential of intelligent technologies in physical education, ensuring their sustainable, equitable, and student-centered implementation.

The research hypothesis is that the effective integration of AI and ICT tools into physical education can significantly enhance the quality of the educational process by increasing student motivation, personalizing the learning experience, and promoting inclusion. However, the success of this integration depends on overcoming a range of technical, pedagogical, and ethical limitations.

2. Materials and Methods

2.1. Experimental Approach to the Problem

This systematic review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines [24–26] and followed the recommendations established for conducting systematic reviews in the field of sport sciences [27]. Its aim was to identify, select, and analyze relevant studies investigating the integration of tools based on artificial intelligence (AI) and information and communication technologies (ICT) in physical education (PE) and physical activity (PA), with a focus on innovations, pedagogical impact, and associated challenges. PRISMA was applied primarily as a reporting guideline to ensure a transparent and consistent presentation of results, adapted to the specific context of sport science, where a strict systematic approach is not always possible. This practice is consistent with approaches documented in related studies.

2.2. Information Sources

The literature search was conducted between November 2024 and April 2025, guided by PRISMA methodology, and targeted studies published primarily in the last five years to ensure the relevance and currency of the findings. Eligible articles were identified in the following international databases: Web of Science, Scopus, MEDLINE/PubMed, and DOAJ—for literature in English. For literature in Romanian, direct access was used on the websites of relevant scientific journals in the field of sport science and physical education. This bilingual search strategy (English + Romanian) ensured broader coverage and contextual relevance.

2.3. Search Strategy

The PICO framework (Patient, Problem, or Population–Intervention or Exposure–Comparison, Control, or Comparator–Outcomes) [28,29] was used to structure the search strategy and ensure systematic coverage of the relevant literature (Table 1).

Table 1. Search strategy framework based on the PICO model adapted to sport sciences: P = children/adolescents in PE; I = AI/ICT; C = traditional PE or other technologies; O = motor, motivational, cognitive, and psychosocial outcomes.

P (Population):	I (Intervention):	C (Comparison):	O (Outcome):
Children and adolescents involved in physical education activities or formal physical activity programs in educational contexts (schools and universities), regardless of their performance level or socio-economic status.	The use of technologies based on artificial intelligence (AI) and information and communication technologies (ICT), including mobile applications, digital educational platforms, biomechanical feedback systems, augmented and virtual reality, and wearable devices.	Traditional physical education programs without the use of AI and ICT tools or, in some cases, comparison between different types of digital technologies (e.g., AR vs. mobile applications).	Improving the educational process, measured by increasing motivation, personalizing learning activities, developing digital skills, supporting vulnerable students, and improving the efficiency of the teaching and assessment process.

In the interest of transparency, the authors were not blinded to the names of the journals or the authors of the manuscripts. The keywords used in our approach included combinations such as “Physical education AND artificial intelligence”, “AI tools AND student engagement in physical education”, “ICT in PE/PA AND learning outcomes”, “PE/PA AND digital inclusion OR gamification”.

For sources in Romanian, equivalent terms were used, adapting the phrases to the specific linguistic reality.

2.4. Eligibility Criteria

The selection of articles was based on their importance in relation to the proposed topic, with a focus on the impact of AI and ICT in PE/PA, especially on the physical, cognitive, and psychosocial aspects of young participants (cognitive = self-regulation, decision-making; psychosocial = motivation, collaboration, reduced anxiety, inclusion).

2.4.1. Inclusion Criteria

Studies that met the following conditions were included in the analysis:

1. Scientific studies that targeted children and adolescents;
2. Research that referred to physical education activities or technology-assisted physical activity;
3. Articles published between 2014 and 2025, focused on physical education in the context of the use of AI/ICT;
4. Experimental or quasi-experimental, qualitative or quantitative studies, including relevant systematic reviews;
5. Scientific articles published only in English and Romanian, in scientific journals with academic visibility (indexed in Scopus/Web of Science or nationally recognized in sport sciences).

We mention the fact that the included population spans children, adolescents, and university students engaged in physical education contexts.

2.4.2. Exclusion Criteria

The following were excluded from the analysis:

- Letters to the editor, short comments, or editorial updates without scientific basis;
- Unpublished papers or papers published in languages other than English or Romanian;
- Studies that did not explicitly address PE/PA and did not address aspects that referred to the use of any technology;
- Scientific communications presented only in the form of posters, conference abstracts, editorials or lectures;
- Articles dated before 2014.

2.5. Selection and Analysis Process

After analyzing all the databases (Web of Science, Scopus, MEDLINE/PubMed, and DOAJ), as well as the websites of relevant scientific journals in the field of sport science and physical education in Romanian, the content of 865 articles (850 + 15) was reviewed. In the first stage, 384 duplicate articles were identified. After removing the duplicates, the authors analyzed whether each of the remaining 398 articles met all the inclusion criteria, which led to the elimination of 357 articles. This was followed by a full-text evaluation, during which another 9 studies were excluded. Of the 32 remaining, 13 were included in the quantitative synthesis of the systematic review. Of the 13 studies, 3 focused on primary education, 5 on gymnasium/high school, and 5 on university students. Nine used ICT, four used AI explicitly. Ten were in English, three in Romanian (Figure 1).

The articles were evaluated in two stages: first by analyzing the title and abstract, and then through full-text reading. Two independent evaluations were conducted for each article, and all discrepancies were resolved through consensus among the authors.

The extracted data were coded according to the following criteria: (1) the type of technology used (AI, ICT, mobile applications, virtual reality, etc.); (2) the target group (age, educational level); (3) the educational dimensions addressed (teaching, assessment, motivation, inclusion); (4) reported challenges; and (5) conclusions regarding effectiveness or limitations.

Screening was conducted independently by two evaluators. Disagreements were resolved by consensus (agreement rate > 85%).

2.6. Assessment of Methodological Quality

To assess the methodological quality of the studies included in this systematic review, the Mixed Methods Appraisal Tool (MMAT), version 2018 [30,31], was used—an internationally recognized tool for the critical appraisal of studies employing diverse methodologies (qualitative, quantitative, and mixed methods). The choice of MMAT was justified by the heterogeneous nature of the included studies, which employed a variety of approaches—from quasi-experimental interventions and descriptive studies to qualitative investigations and mixed-method designs. This choice was motivated by the heterogeneous nature of the included studies (quantitative, qualitative, and mixed), ensuring coherent evaluation.

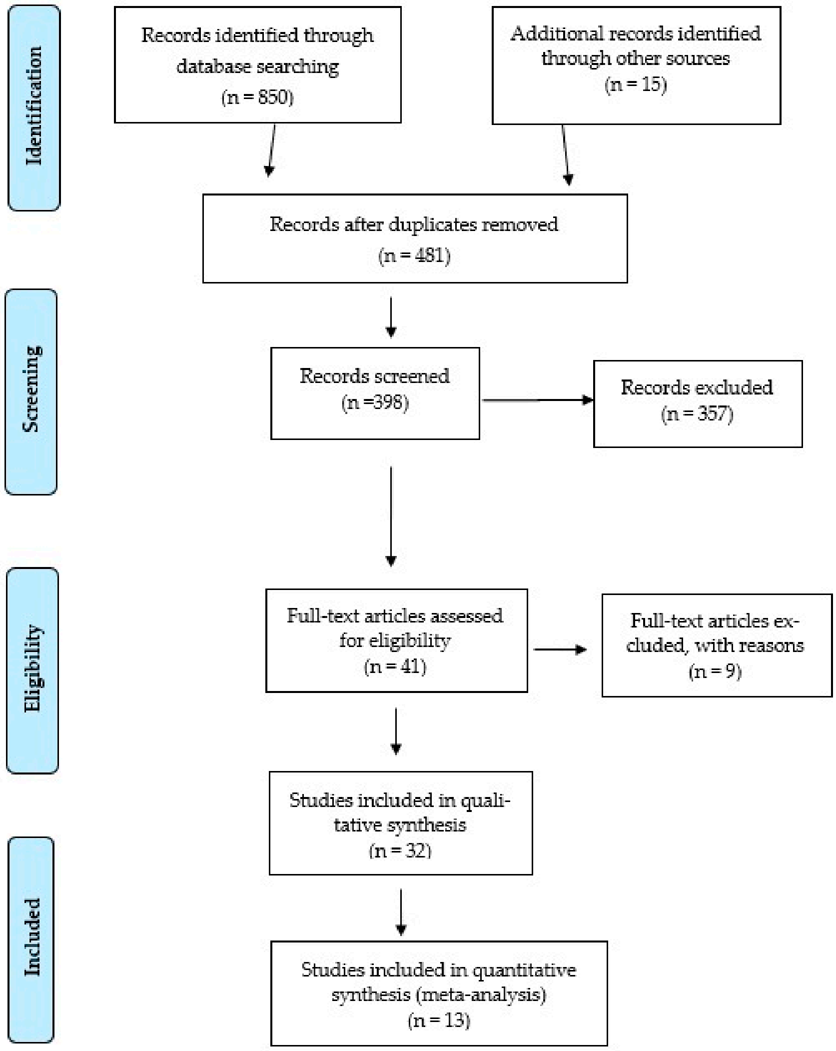

Figure 1. PRISMA flow diagram of study selection.

Of the 13 studies reviewed (n = 13), most (n = 9) were quantitative descriptive studies. Two studies used a mixed-method approach, and two were qualitative in nature.

- A total of 3 studies (23%) scored 80% (4/5 criteria), being considered good quality.
- Eight studies (62%) scored 60% (3/5 criteria), reflecting moderate quality.
- Two studies (15%) scored 40%, indicating low quality, mainly due to the lack of rigorous sampling methods and validation of instruments (Table 2).
  The main methodological shortcomings identified include lack of comparison groups, lack of adjustment for confounders, data collection instruments without documented validation, and lack of clarity in describing data analysis.

2.7. Registration and Protocol

This systematic review was not registered in PROSPERO or any other platform. A protocol was not prepared.

Table 2. Methodological quality assessment using MMAT (2018) for included studies.

No.	Author And Year	MMAT Method Type	No. of "Yes/Clearly Yes" Criteria (out of 5)	Score (%)	Quality Interpretation
1	Culajara (2023) [32]	Mixed methods (pre-post + focus group)	3	60%	Moderate
2	Nieto et al. (2022) [33]	Quantitative descriptive (self/peer evaluation)	2	40%	Low–moderate
3	Wallace, Scanlon & Calderón (2023) [34]	Quantitative descriptive (perception survey)	3	60%	Moderate
4	Montiel Ruiz et al. (2023) [35]	Qualitative (case study: focus group/interview)	4	80%	Good
5	Ahmed & Sarkar (2022) [36]	Presumed descriptive (ICT intervention)	2	40%	Low–moderate
6	Koh et al. (2022) [37]	Quantitative descriptive (perception survey)	3	60%	Moderate
7	Cao et al. (2022) [38]	Quantitative descriptive (AI system)	3	60%	Moderate
8	Mukan et al. (2021) [39]	Quantitative descriptive (static balance test)	3	60%	Moderate
9	Deng et al. (2024) [40]	Quantitative descriptive (governance survey)	3	60%	Moderate
10	Trabelsi et al. (2022) [41]	Quantitative descriptive (national teacher survey)	4	80%	Good
11	Jun et al. (2024) [42]	Quantitative descriptive (blockchain/ML)	3	60%	Moderate
12	Tagimaucia et al. (2024) [43]	Mixed methods (exploratory review from title)	4	80%	Good
13	Poulitsa et al. (2025) [44]	Quantitative descriptive (ICT emotional impact)	3	60%	Moderate

3. Results

This systematic review synthesized 13 relevant studies, providing a structured perspective on AI and ICT applications in physical education. The results are thematically organized, reflecting four major directions: (1) typologies of technology use, (2) pedagogical and motivational impact, (3) challenges and barriers in implementation, and (4) solutions identified in the specialized literature. Each direction is supported by summary tables, analytical interpretations, and correlations between studies.

3.1. Typologies of AI and ICT Applications in Physical Education

The analyzed studies identify four main categories of AI and ICT use in physical education: motor e-learning, self-monitoring, biomechanical feedback, and VR/AR-assisted teaching. These reflect a diversification of technological approaches depending on the pursued pedagogical objectives, the targeted educational level, and the type of technology applied. It is worth noting that although technologies such as virtual reality and augmented reality (VR/AR) are often classified as ICT, their advanced implementation for adaptive learning and personalized feedback is often influenced by artificial intelligence algorithms, which make the differences between the two categories increasingly difficult to notice, thus leading to the emergence of tools that work well together. For example, motor e-learning supports visual and asynchronous instruction, especially targeting secondary and higher education. Mobile applications for self-monitoring aim at students' self-regulation, while wearable devices and biomechanical sensors are used for movement analysis and improving execution precision. VR/AR allows for interactive simulation of motor gestures, being predominantly applied in lower and upper secondary education (Table 3).

AI was defined as systems using machine learning, motion recognition, or automated feedback. ICT included broader digital tools such as Learning Management Systems (LMSs), VR/AR, mobile applications, and wearables. Results are presented in separate AI-specific and ICT-general subsections.

This technological diversity does not occur in isolation, but as part of a hybrid pedagogy in which digital tools can be complementarily integrated to support motor, cognitive, and social learning.

These directions highlight a diversity of educational purposes. Motor e-learning supports visual learning and asynchronous instruction, responding to the need for flexibility in teaching. Self-monitoring applications, such as those documented by Montiel-Ruiz et al. [35] and Ahmed & Sarkar [36], encourage self-regulation and the development of intrinsic motivation. Biomechanical feedback, based on sensors and wearable devices, supports posture correction and the efficiency of motor training. Last but not least, the use of VR/AR technologies in teaching gestures introduces elements of increased interactivity and immersion, especially at the middle and high school levels.

Table 3. Types of AI and ICT applications in physical education.

Field of Use	Relevant Studies	Technology Used	Priority Direction	Target Educational Level
Motric e-learning	Culajara (2023) [32], Nieto et al. (2022) [33], Wallace et al. (2023) [34]	Interactive video platforms, LMSs	Supporting visual learning and distance learning	Gymnasium, high school, university
Self-monitoring	Montiel-Ruiz et al. (2023) [35], Ahmed & Sarkar (2022) [36], Koh et al. (2022) [37]	Mobile applications with logging and self-assessment functions	Developing self-regulation and personal motivation	Elementary, gymnasium, university
Biomechanical feedback	Cao et al. (2022) [38], Mukan et al. (2021) [39], Deng et al. (2024) [40]	Motion sensors, wearable devices	Posture and movement analysis and correction	High school, university
Teaching gestures with VR/AR	Trabelsi et al. (2022) [41], Jun et al. (2024) [42], Tagimaucia et al. (2024) [43]	Virtual and augmented reality	Motric simulations and increased interactivity	Gymnasium, high school

The results suggest that these applications are not mutually exclusive, but can coexist in a complementary pedagogical approach, contributing to the development of students' motor, cognitive and social skills.

3.2. The Pedagogical and Motivational Impact of AI and ICT

The use of AI and ICT generates notable educational benefits, highlighted in the literature through three main mechanisms: providing real-time feedback, personalizing tasks, and supporting the inclusion of vulnerable students. Instant feedback, obtained through sensors and algorithms, supports rapid correction of movements and improves students' self-efficacy. This approach contributes to an active and self-regulated learning process. Individualizing exercise programs allows for the adaptation of the degree of difficulty and motor content, depending on the progress of each student, demonstrating the potential of these technologies for student-centered education.

Furthermore, the application of technology to support students with disabilities or psychosocial difficulties shows the inclusive valences of ICT, facilitating the adaptation of exercises and reducing performance anxiety. These findings indicate a transformation of the educational relationship, from a frontal, uniform one, to a personalized and flexible one, supported by smart technologies. Table 4 summarizes these effects.

Table 4. Pedagogical and motivational impact of integrating AI and ICT in physical education.

Impact Indicator	Relevant Studies	Description	Observations
Real-time feedback	Mukan et al. (2021) [39], Wallace et al. (2023) [34], Deng et al. (2024) [40]	Sensors and AI provide instant feedback, supporting correction and self-efficacy	Contributes to increasing internal motivation
Individualizing the exercise program	Cao et al. (2022) [38], Jun et al. (2024) [42], Koh et al. (2022) [37]	AI personalizes difficulty level and motor content based on student progress and preferences	Promising applications but still limited in widespread use
Support for vulnerable learners	Poulitsa et al. (2025) [44], Montiel-Ruiz et al. (2023) [35], Tagimaucia et al. (2024) [43]	Using technologies to reduce anxiety, support inclusion, and adapt exercises	ICT can support the participation of students with disabilities or psychosocial difficulties

Real-time feedback, provided through sensors and AI algorithms, allows for the immediate correction of movements and reinforces the sense of personal efficacy. The personalization of exercises according to individual progress reflects the adaptive potential of these technologies, especially in the context of emerging platforms. Moreover, the support offered to vulnerable students—including those with disabilities or psychosocial difficulties—demonstrates the technologies' ability to promote inclusion and active participation.

These findings suggest that AI and ICT not only support the educational process but can structurally transform it by stimulating student autonomy and encouraging a pedagogical approach centered on individual needs.

3.3. Challenges and Barriers in Implementation

Despite the remarkable benefits, the academic literature highlights a series of systemic obstacles. The most frequently identified barriers include the following: (1) inequalities in access to digital infrastructure, known as the "digital divide"; (2) lack of adequate digital training among teaching staff; (3) ethical concerns regarding the collection and use of personal data; and (4) technical limitations in applying technologies in dynamic environments such as outdoor activities (see Table 5).

Table 5. Challenges and barriers in integrating AI and ICT in physical education.

Type of Challenge	Relevant Studies	Description	Target Educational Level
Digital divide (inequality of access)	Trabelsi et al. (2022) [41], Ahmed & Sarkar (2022) [36], Tagimaucia et al. (2024) [43]	Inequalities in access to digital infrastructure between urban and rural areas, as well as between developed and developing countries	Public schools in peripheral areas, countries with limited resources
Lack of digital training for teachers	Wallace et al. (2023) [34], Koh et al. (2022) [35], Poulitsa et al. (2025) [44]	Lack of digital skills among teachers limits the effective use of modern technologies	Physical education teachers in primary and secondary education
Ethical and data concerns	Deng et al. (2024) [40], Jun et al. (2024) [42], Montiel-Ruiz et al. (2023) [35]	The use of wearables and apps in education is often accompanied by a legislative vacuum regarding data privacy	Applications with biometric tracking, online learning environments
Technical limitations in outdoor environments	Mukan et al. (2021) [39], Culajara (2023) [32], Trabelsi et al. (2022) [41]	AI and ICT are difficult to apply in dynamic contexts (outdoor activities)	Outdoor lessons, lack of connectivity, or instability in measurements

These challenges are not isolated but interdependent: lack of infrastructure limits the application of technology, and lack of training hinders its effective use. At the same time, issues related to data privacy and protection become central in the context of wearable use and online environments, requiring a clear legal framework and ethical digital literacy.

Among the most common barriers is the inequality of access to digital infrastructure, a phenomenon that is more pronounced in rural areas and underfunded regions. Additionally, the lack of adequate teacher training limits their ability to effectively use new technologies. Other significant obstacles are related to the risks concerning the protection of personal data collected through applications and wearables, as well as technical difficulties encountered during outdoor activities (poor connectivity, interference).

These findings highlight the importance of an integrated approach to digital transformation in education, in which equity, safety, and professional competencies become essential conditions.

3.4. Intervention Directions for Overcoming Limitations

The literature also offers realistic solutions for overcoming these challenges. Among the most frequently suggested interventions are the development of open-source resources adapted to disadvantaged environments, continuous teacher training in advanced digital competencies (including the use of VR/AR), the promotion of autonomous technologies for environments without constant internet access, and the development of an ethical and legal framework specifically for the use of AI in education (Table 6).

Table 6. Intervention directions to mitigate limitations.

Limits	Relevant Studies	Intervention Directions	Observations
Unequal access	Tagimaucia et al. (2024), [43] Ahmed & Sarkar (2022) [36]	Developing open-source educational materials and optimizing applications for environments with limited technological infrastructure	It assumes the involvement of the authorities
Insufficient training	Wallace et al. (2023) [34], Poulitsa et al. (2025) [44]	Continuous improvement programs in digital skills for teachers	Integrates the development of AR/VR skills and familiarization with mobile educational tools
Outdoor limitations	Mukan et al. (2021) [39], Cao et al. (2022) [38]	Using sensors that do not require a permanent internet connection and developing resilient equipment	Encouraging technological experimentation in PE
Personal data	Deng et al. (2024) [40], Jun et al. (2024) [42]	Creating an ethical framework for the use of technology, complemented by information and training actions for beneficiaries	It assumes a connection between the fields of information technology and legal regulations

The success of these interventions, however, depends on the simultaneous involvement of institutional actors (policymakers, school managers), technology developers, and practitioners.

The results of this systematic review highlight the significant potential of AI and ICT in transforming physical education towards a more flexible, personalized, and inclusive model. The benefits identified—from real-time feedback to support for vulnerable students—are significant, but they cannot be fully realized without addressing systemic challenges, such as insufficient professional training and lack of infrastructure.

This analysis confirms that AI and ICT can act as accelerators for the re-shaping of physical education, but requires an integrated vision, focused on equity, safety, and pedagogical quality. In this sense, the studies reviewed provide not only a mapping of the current state of technological integration in PE, but also a guiding framework for future educational policies and institutional initiative.

Table 7 summarizes the main characteristics of the included studies, such as sample size, outcome measures, type of effect observed, and its size. This presentation facilitates comparison of methodological approaches and conclusions formulated in the reviewed literature.

Table 7. Descriptive characteristics and main findings of included studies on AI and ICT integration in physical education.

No.	Author/Year	Sample Size	Outcome Measures	Main Findings/Effect Description	Effect Size
1	Culajara (2023) [32]	52 students + 5 in focus group	Pre-test/post-test scores	Video-based presentations (VBP) significantly improved learning performance	Not reported
2	Nieto et al. (2022) [33]	38 students (age 15)	Self-assessment, peer-assessment via Plickers	Authentic + transformative assessment positively received	Not reported
3	Wallace et al. (2023) [34]	N/A (qualitative study)	Teacher and student perceptions	Low digital competence hinders tech integration in PE	Not reported
4	Montiel-Ruiz et al. (2023) [35]	56 students + 10 teachers	Interviews and focus groups	Edmodo + gamification increased physical activity engagement	Not reported
5	Ahmed & Sarkar (2022) [36]	N/A	Observational and narrative analysis	ICT enhances teaching and learning processes in PE	Not reported
6	Koh et al. (2022) [37]	11 teachers + 72 students	Interviews and focus groups	Positive perceptions but low digital skills among teachers	Not reported
7	Cao et al. (2022) [38]	N/A	AI + multimedia performance tracking	Intelligent system showed promising results in PE monitoring	Experimental results positive, no exact figures
8	Mukan et al. (2021) [39]	N/A	Static balance testing via ICT	Innovative assessment method using multivariate analysis	Not reported
9	Deng et al. (2024) [40]	N/A	Theoretical + case-based analysis	Smart governance in PE using next-gen IT	Not reported

Table 7. *Cont.*

No.	Author/Year	Sample Size	Outcome Measures	Main Findings/Effect Description	Effect Size
10	Trabelsi et al. (2022) [41]	424 teachers	Quick Tech Survey questionnaire	Low ICT usage but generally positive attitudes	Not reported
11	Jun et al. (2024) [42]	N/A	ML algorithms + blockchain	Correlation between behavior and physical performance	F1 = 0.928; Calinski–Harabasz > 240
12	Tagimaucia et al. (2024) [43]	35 teachers	Questionnaire + interviews	Online PE challenged by connectivity and resource gaps	Not reported
13	Poulitsa et al. (2025) [44]	N/A (conference paper)	Emotional well-being assessment + ICT tools	ICT in PE improved emotional state of vulnerable students	Not reported

4. Discussion

The results of the present study provide a coherent perspective on teachers' perceptions of the integration of artificial intelligence (AI) in primary physical education classes. Overall, the data show a positive attitude towards the potential of these technologies to support personalized learning, streamline the assessment process, and increase student motivation and engagement. This receptivity is aligned with recent developments in the international literature on the digital transformation of physical education teaching. For instance, AI-assisted gamification and AR tools increase active involvement, especially in less motivated students.

Most findings reflect self-reported perceptions, not objective motor performance data. Evidence for objective improvements remains preliminary.

Furthermore, the convergence of teachers' perceptions and empirical evidence provides a strong argument for reconsidering curriculum design in physical education, in a manner compatible with digital environments and artificial intelligence.

The first direction identified in the empirical data is related to personalizing learning and adapting tasks to the pace and level of each student. Teachers interviewed in our study acknowledge that AI can allow them to dynamically adjust requirements according to individual student performance levels, thus providing a differentiated learning environment. Kaya (2025) [45] argues that artificial intelligence contributes to this process through algorithms that can analyze students' motor activity in real time and provide immediate corrective feedback, thus increasing learning efficiency. Similarly, Cui et al. (2025) [46] emphasize that AI can generate automated reports and differentiated training programs, depending on the observed progress of each individual. These results indicate significant potential for promoting student-centered physical education, in which AI functions not only as a support tool, but also as a mediator between teaching and learning.

This adaptive capacity is amplified by the integration of wearable technologies and IoT (Internet of Things), which allow for the measurement of physiological and biomechanical parameters during motor activities. In this sense, Montiel-Ruiz et al. (2023) [35] have demonstrated that the use of smart devices in physical education increases students' self-efficacy and allows teachers to intervene with quick and precise adjustments. At the same time, these devices contribute to the development of data-driven teaching, which optimizes not only student activity, but also instructional decisions in real time. These findings are corroborated by other scientific studies addressing similar topics [47,48].

The second major theme identified is the increase in student motivation and the improvement of their engagement in physical activities. Teachers observe that AI-assisted environments, especially those including augmented reality, mobile applications, or educational games, lead to more active student participation, particularly among those with low interest in traditional physical activities. This finding is supported by Modra et al. (2021) [17], who identified a direct correlation between the use of digital technologies and increased student motivation, especially through flipped learning methods and video-assisted assessment. Likewise, Wallace et al. (2024) [34] emphasize that artificial intelligence, combined with gamification elements, fosters a positive attitude among students toward motor activities. This suggests that AI can function as an emotional and cognitive catalyst, reducing resistance to physical effort and transforming the educational experience into one perceived as meaningful and enjoyable. These mechanisms are interpreted through the lens of Self-Determination Theory and the Guidance Hypothesis.

In terms of learning autonomy, interviewed teachers highlight that intelligent technologies can support the development of students' self-assessment abilities through visual feedback and self-monitoring. This direction is confirmed by Dahri et al. (2024) [49] and Khasawneh et al. (2025) [50], who show that AI-assisted platforms enhance self-regulation and the development of personal responsibility in students toward their own learning process. Complementarily, Ahmed (2023) [51] and Tariq et al. (2025) [52] indicate that the integration of AI contributes to the development of integrated health, including physical, psychosocial, and cognitive aspects, within a student-centered curricular model. These findings are consistent with contemporary models of transformative learning, in which the student is not merely a beneficiary but also a co-author of their own development.

Another significant result of the study is the perceived relevance of AI in assessing student performance, with a focus on objectivity and efficiency. Teachers mention that intelligent technologies allow for the generation of real-time results, reducing the time required for the evaluation process and providing standardized indicators. This view aligns with the research of Song et al. (2024) [53], who argue that AI optimizes physical testing processes and the identification of intervention needs, and with that of Wang & Wang (2024) [54], who indicate an increase in the quality of formative assessment through the use of motor analysis algorithms. This strengthens the idea of an objective pedagogy, supported by digital evidence and the reduction in subjective errors in the assessment of motor performance.

At the same time, teachers point out a series of structural and pedagogical barriers to the integration of AI in physical education, the most important being the lack of professional training, insufficient technological infrastructure, and cultural reluctance. These obstacles are also highlighted by Shrestha (2025) [18], who shows that in many educational contexts, technology integration is limited by social inequalities and the lack of institutional support. Similarly, Jastrow et al. (2022) [55] warn about the risks related to data privacy and the need for a clear legal framework for the use of AI in schools. These aspects confirm that technological progress in education is not autonomous but fundamentally depends on contextual support, including legislative, training, and infrastructural factors. An important ethical dimension is also captured in this study: the protection of students' personal data and the transparency of algorithms used in educational platforms. This concern is legitimate, given that AI involves continuous data collection and processing, which implies an increased risk of intrusion and misuse of sensitive information. Hu et al. (2024) [56] argue that the development of a clear regulatory framework and the training of teachers in digital ethics are essential steps for the sustainable implementation of AI in education. This ethical component becomes even more relevant in physical education, where the data are often biometric and can affect students' self-image.

In addition to challenges, the results also highlight the potential of AI to contribute to educational equity, especially through the adaptability of content for students with special educational needs or from vulnerable backgrounds. In this regard, Habib et al. (2022) [57] explore how AI can support the active participation of students with mild disabilities through interactive digital games and visual feedback, and Zhang et al. (2022) [58] demonstrate that adaptive AI platforms reduce performance gaps between urban and rural students. This transformative potential of AI is not only technological but also deeply social, as it aims to reduce disparities and democratize access to quality physical education. Recent studies [43–46] reinforce the relevance of digital tools in PE across diverse contexts.

In summary, the results of our study are consistent with major trends highlighted in the specialized literature, outlining a consensus regarding the usefulness and potential of AI in transforming the educational process in the field of physical education. However, for this transformation to be real, sustainable, and equitable, it is essential that educational decision-makers support teachers through continuous training programs, investments in infrastructure, and the development of an ethical and legislative framework adapted to new technological realities.

4.1. Limitations of the Systematic Review

This systematic review presents a number of limitations that must be taken into account when interpreting and generalizing the results. Firstly, the selection of sources was limited to studies available in English and Romanian, which may lead to the exclusion of relevant contributions from other cultural and educational contexts. Moreover, a significant part of the included literature comes from exploratory or pilot studies with diverse methodologies, making it difficult to directly compare the results.

Another major limitation is the absence of a quantitative meta-analysis. Most of the analyzed sources are qualitative or conceptual in nature, which reduces the possibility of drawing strong statistical conclusions about the actual effectiveness of artificial intelligence in physical education. In addition, the reviewed studies largely reflect the opinions of teachers and students' subjective evaluations, without a broad empirical base to track long-term objective performance.

Regarding the primary source of the study—our own article—the qualitative data obtained through semi-structured interviews are valuable for understanding teachers' perceptions but cannot be extrapolated without caution to the entire educational system due to the sample size and its exploratory nature. Furthermore, the lack of triangulation with other categories of educational stakeholders (e.g., students, parents, decision-makers) limits the multi-level perspective of the analysis.

Last but not least, the rapid pace of technological development means that some of the applications and platforms analyzed may quickly become outdated or replaced, which affects the long-term stability of the conclusions. Therefore, the results of this review should be seen as a snapshot in time, with theoretical and methodological guidance value, but requiring continuous updating and extensive empirical validation.

This review also has other limitations: the lack of prospective protocol registration, which may affect the transparency and reproducibility of the analysis, and the exclusive selection of studies in English and Romanian, which may limit the applicability of the results to more diverse educational contexts. In future research, protocol registration and expansion of linguistic criteria could increase the methodological rigor and international relevance of the conclusions.

4.2. Future Research Directions

Going forward, research will need to focus on evaluating the real and lasting effects of integrating artificial intelligence into physical education, moving beyond perceptions and stated intentions. Longitudinal and comparative empirical studies will be essential to determine the extent to which these technologies influence students' motor development, motivation, and engagement. It is also important that future research addresses multiple perspectives—those of students, parents, and educational decision-makers—to form a more complete picture of the acceptance and usefulness of these tools. Lastly, the development of integrated pedagogical models that combine motor skills with digital literacy and learning autonomy will represent a fundamental challenge for future educational research.

5. Conclusions

This review highlights that AI and ICT also directly support motor skill development, e.g., through biomechanical feedback for correcting gestures, VR for safe practice of motor tasks, and self-monitoring apps for fitness. These benefits coexist with challenges (infrastructure gaps, teacher training, and data ethics).

The integration of digital technologies and artificial intelligence in physical education represents a promising approach with the potential to transform teaching practice, motor learning, and student motivation.

The results of this systematic review highlight that artificial intelligence (AI)-based technologies and ICT tools can represent significant vectors of transformation in contemporary physical education, at all levels of education. Emerging applications, from real-time biomechanical feedback to augmented reality and self-monitoring solutions, shape a student-centered digital pedagogy that favors the personalization of learning, the development of self-efficacy and the inclusion of students with diverse needs. The studies analyzed support the potential of these technologies to facilitate the transition from standardized, frontal teaching to a flexible, adaptable, and interactive instructional model.

Teachers' perceptions indicate a positive receptivity towards AI, motivated by the pedagogical and functional advantages of these tools. Personalizing exercises, quick access to standardized feedback, and the ability to adapt to different learning rhythms are recurring elements in teachers' testimonies. At the same time, AI is perceived as a facilitator of inclusion, allowing the adaptation of activities for students with disabilities or integration difficulties. Nevertheless, for such a transformation to take root in a meaningful and equitable way, it requires committed support from educational policymakers. This includes sustained investment in teacher training, infrastructure upgrades, and the creation of a clear ethical and legal framework aligned with emerging technological realities. These challenges can act as inhibiting factors for progress, especially in educational systems with limited resources. In this context, a systemic vision of the digital transformation in physical education is essential, which articulates technological innovation with the real needs of educational actors. There is a need for educational policies focused on digital equity, continuous training programs adapted to the bodily and relational specificity of the discipline, as well as coherent investments in educational infrastructure. Only through an integrated and ethical approach can digital technologies authentically contribute to the democratization of physical education and the development of a culture of active, interactive, and inclusive learning.

Teachers → need targeted digital training. Students → equitable access to inclusive technologies. Schools → infrastructure investments. Policymakers → ethical/legal frameworks for AI in PE.

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