Artificial Intelligence in elite sports training and prospects for integration into school sports

Inteligencia Artificial en el entrenamiento deportivo de élite y perspectiva de su integración en el deporte escolar

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Abstract

Introduction: artificial intelligence (AI) is a constant presence in elite sports training today, enabling performance analysis, personalized training, and injury prevention. The transfer of these innovative technologies to school sports, although still at an early and insufficiently documented stage, has started to gain visibility.
Objective: the article aims to analyze the presence of artificial intelligence in elite sports training and explore the prospects for integrating these technologies into school sports.
Methodology: A systematic review of recent literature from the main scientific databases was conducted, together with a detailed analysis of practical applications of artificial intelligence in elite sports training.
Results: AI use in elite sports is reflected in advanced systems for performance analysis and optimization. Although its implementation in school sports is currently limited by high costs and insufficient infrastructure, real opportunities exist for integrating similar technological solutions tailored to the specific needs and possibilities of schools.
Discussion: results suggest a significant potential for transferring AI technologies to school sports, provided that clear educational policies and investments are implemented.
Conclusions: the gradual and adapted integration of artificial intelligence in school sports can significantly modernize physical education and enhance the quality of sports training in schools.

Keywords

Artificial intelligence; elite sports; performance analysis; school sports; sports training.

Resumen

Introducción: la inteligencia artificial (IA) es una presencia constante en el entrenamiento deportivo de élite actual, facilitando el análisis del rendimiento, la personalización del entrenamiento y la prevención de lesiones. La transferencia de estas tecnologías innovadoras al deporte escolar, aunque aún en una etapa inicial e insuficientemente documentada, ha comenzado a ganar visibilidad.
Objetivo: el artículo tiene como objetivo analizar la presencia de la inteligencia artificial en el entrenamiento deportivo de élite y explorar las perspectivas para integrar estas tecnologías en el deporte escolar.
Metodología: se realizó una revisión sistemática de la literatura reciente en las principales bases de datos científicas, junto con un análisis detallado de las aplicaciones prácticas de la inteligencia artificial en el entrenamiento deportivo de élite.
Resultados: el uso de la IA en el deporte de élite se refleja en sistemas avanzados para el análisis y la optimización del rendimiento deportivo. Aunque su implementación en el deporte escolar está actualmente limitada por altos costes e infraestructura insuficiente, existen oportunidades reales para integrar soluciones tecnológicas similares adaptadas a las necesidades y posibilidades específicas de las escuelas.
Discusión: los resultados sugieren un potencial significativo de transferencia de las tecnologías de IA al deporte escolar, condicionado a la implementación de políticas educativas claras e inversiones específicas.
Conclusiones: la integración gradual y adaptada de la inteligencia artificial en el deporte escolar puede contribuir significativamente a la modernización de la educación física y mejorar la calidad del entrenamiento deportivo en las escuelas.

Palabras clave

Análisis del rendimiento; deporte escolar; entrenamiento deportivo; inteligencia artificial; rendimiento deportivo.

Introduction

Artificial intelligence (AI) has emerged as a fundamental element in contemporary sports training, becoming increasingly prominent within elite sports contexts. The integration of AI-driven technologies has led to substantial transformations in how athletic performance is analyzed, developed, and optimized. Today, advanced AI systems facilitate real-time monitoring of physiological parameters, precise assessment of physical workloads, injury prediction, and the individualization of training protocols based on comprehensive biometric data. These technological innovations have significantly enhanced decision-making processes for coaches, trainers, and medical teams, allowing for data-driven interventions aimed at maximizing athletic potential. Additionally, sophisticated predictive models now provide insights previously unattainable through conventional methods, enabling the anticipation of performance fluctuations and potential injury risks. The effectiveness of AI in enhancing sport-specific outcomes is well documented, marking a clear paradigm shift from traditional empirical coaching methods toward evidence-based, data-intensive approaches (Araújo et al., 2025; Hammes et al., 2022; Bartlett et al., 2022; Mănescu et al., 2025; Munoz-Macho et al., 2024).

However, despite these significant advancements in elite sports, the integration of AI-based technologies into school sports remains at an early and relatively unexplored stage. Current literature reveals only a limited number of systematically documented cases of practical AI implementation in physical education contexts. This gap highlights a clear necessity to explore the possibilities, barriers, and conditions under which technologies developed for elite sports can be effectively adapted and transferred into school environments. Such integration holds considerable potential for enhancing students' physical and educational development by offering more personalized, engaging, and effective training experiences. Addressing these possibilities is critical given the rising demand for innovative educational methods and the global emphasis on youth health and physical activity (Bailey et al., 2023; Kirk, 2022; Ruiz-Juan, F., & Piéron, M.; Enright & Gard, 2022; Van der Mars & Harvey, 2020).

Therefore, this article aims to examine the current state of AI integration within elite sports and to investigate the potential and prerequisites for its effective adoption into school sports contexts. By providing a clear, practical, and well-structured conceptual framework, the study seeks to contribute significantly to the modernization of teaching methodologies and the enhancement of training processes used in school physical education.

Literature review

Artificial intelligence (AI) is fundamentally reshaping sports training by integrating sophisticated analytics and advanced technological applications in elite athletic contexts. AI's capability to rapidly process extensive datasets has significantly enhanced training methodologies, athlete development, and performance optimization. Recent developments highlight AI's role in refining individualized training programs, monitoring athletes' physiological status, managing injury risks, and optimizing competitive strategies (Zhang & Liu, 2025; Claudino et al., 2019; Jaspers et al., 2018; Li et al., 2021; Olmos Gomez et al., 2025).

A prominent application of AI involves biometric monitoring and physiological tracking. Wearable sensors integrated with AI algorithms facilitate real-time monitoring of critical physiological parameters such as heart rate variability, oxygen consumption, muscle fatigue, hydration levels, and overall physiological load. These advanced technologies enable precise tailoring of training sessions according to the athlete's immediate condition, greatly reducing the risk of fatigue-related injuries and enhancing recovery processes (Goes et al., 2021; Rein & Memmert, 2016; Mohammed et al., 2024; Sanabria Navarro, 2024).

Predictive analytics utilizing AI have significantly improved injury prevention strategies. Machine learning algorithms analyze historical performance and biometric data to detect subtle changes that indicate heightened injury risk. These predictive models enable coaches and medical teams to proactively modify training loads, substantially decreasing injury occurrence in elite sports (Killoughery & Pitsiladis, 2024; Mănescu, 2025; Ramkumar et al., 2022; Gao et al., 2025; N. Omarov et al., 2024).

AI's application in tactical and strategic sports analysis represents another critical advancement. Machine learning and computer vision techniques enable sophisticated analysis of video footage from competitions and training sessions, providing detailed insights into tactical efficiency, player positioning,

and decision-making patterns. This facilitates improved strategic planning, real-time tactical adjustments, and informed decision-making during competitive events, significantly enhancing overall team performance (Pérez Triviño, 2021; Cardona et al., 2023; Owoc et al., 2021; Kaldarova et al., 2024).

Personalization of training regimens using AI-driven analytics has also proven highly effective. Advanced algorithms analyze extensive historical and current performance data to create highly individualized training plans, optimizing athletes' physiological adaptations and ensuring peak performance at crucial competitive moments. Such personalization significantly enhances athletic outcomes, reduces injury risks, and improves athletes' longevity in sport (Gong, 2025; Carrio Sampedro, 2024; Sánchez Ramírez et al., 2024; Dudek et al., 2025; Zhekambayeva et al., 2024).

Despite substantial advancements at elite levels, the adoption of AI within educational contexts, particularly in school sports programs, remains limited and inconsistent. Existing research consistently identifies significant barriers, including the high costs of advanced technological equipment, inadequate infrastructure within educational institutions, and a notable lack of simplified, user-friendly technological solutions adapted specifically for school use. These limitations severely restrict the accessibility and practicality of AI for school-based physical education (Bădău et al., 2025; Seo et al., 2025; Seshadri et al., 2021; McLaren et al., 2021; B. Omarov et al., 2024b).

Educators' readiness and acceptance of AI also impact its integration into school settings. Research reveals many physical education teachers perceive themselves as insufficiently prepared or supported to effectively integrate advanced technologies into their daily teaching practices. Targeted professional development initiatives and ongoing educational training designed specifically for teachers can address these issues, enhancing educators' capabilities and willingness to adopt AI solutions (Bădău et al., 2023; Wojciech et al., 2025; Weerarathna et al., 2023; Casey et al., 2021; Mulato et al., 2024).

Nonetheless, school settings offer unique opportunities for adopting AI technologies. Pilot programs employing simplified AI-driven wearables and interactive digital platforms have already demonstrated significant improvements in student engagement and learning outcomes in physical education classes. Such technologies hold substantial promise for enhancing physical literacy, motor skill development, student motivation, and overall health and wellness outcomes (Ruiz-Juan, F. & Baena Extremera, A.; Correia & Hickey, 2024; Al Ardha et al., 2024).

AI-driven gamification approaches further present exciting potential in educational contexts. Incorporating game-based methods with AI-enhanced feedback mechanisms can greatly boost student participation, enjoyment, and sustained involvement in physical activities. Gamified environments encourage positive attitudes toward lifelong physical activity and can effectively address declining physical activity trends among youth (Chen et al., 2020; Kaya, 2025; Nahavandi & Seshadri, 2021; Bolatuly Omarov et al., 2025).

The integration of virtual reality (VR) and AI technologies into physical education also marks a transformative educational advancement. VR-based training modules, enhanced by AI algorithms, allow students to safely experience complex motor tasks and diverse sporting environments in an engaging, immersive setting. This technology facilitates efficient skill acquisition, builds confidence, and significantly increases student enjoyment and active participation in physical education (Ţifrea et al., 2015; Yildirim & Correia, 2020; Sureshbabu & Lavaraju, 2024; B. Omarov et al., 2024a).

Crucially, the literature emphasizes the necessity of establishing clearly structured frameworks, comprehensive policy guidelines, and dedicated funding mechanisms to support successful AI integration into educational contexts. Without supportive policies, appropriate investment, and clear educational guidance, the implementation of advanced AI solutions within schools risks remaining fragmented, ineffective, and unsustainable.

In conclusion, effectively bridging the gap between elite sports AI applications and school-based physical education is not only feasible but essential. Systematic research, sustained strategic investments, tailored professional development for educators, and supportive policy initiatives are fundamental to realizing the full educational and developmental potential of AI technologies in schools.

Method

Understanding how technological innovations such as artificial intelligence (AI) transfer effectively from elite sporting environments into educational contexts requires a rigorous and systematic methodological approach. Such an approach not only ensures the reliability and validity of the findings but also provides critical insights into the complex conditions that influence successful implementation. Therefore, the methodological framework employed in this study was carefully designed to identify, select, and analyze the most relevant existing literature, providing a robust foundation for exploring AI's potential within school-based sports training and physical education. This systematic review was conducted in accordance with the PRISMA 2020 guidelines (Page et al., 2021).

Sample

The sample for this study consisted of peer-reviewed scientific publications identified and selected through a comprehensive and systematic search strategy. The initial literature search targeted three primary scientific databases: Web of Science, Scopus, and PubMed. These databases were chosen for their extensive coverage of high-quality, peer-reviewed literature relevant to both sports sciences and educational technologies.

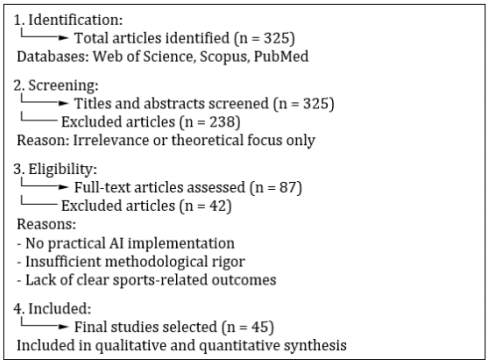
The search process utilized targeted keywords and key phrases specifically tailored to capture relevant literature addressing artificial intelligence applications in elite sports and school sports contexts. Primary keywords included: "artificial intelligence," "machine learning," "sports training," "elite sports," "school sports," "physical education," "performance analysis," and "injury prevention." To ensure the currency and relevance of the research, the search was restricted to publications from the previous five years (2020-2025).

This initial search yielded a total of 325 scientific articles. Following this, the articles underwent a rigorous two-stage screening process. In the first stage, the titles and abstracts were carefully reviewed to determine their relevance to the study objectives, specifically targeting articles explicitly addressing practical implementations or evaluations of AI technologies in sports contexts. Articles focusing exclusively on theoretical aspects without practical implications or lacking clear connections to sports training or educational contexts were excluded at this stage. This initial screening reduced the selection to 87 potentially relevant articles.

In the second stage, full-text evaluations were performed on the remaining 87 articles to confirm eligibility based on detailed inclusion criteria. Articles were included if they provided clear documentation of AI-driven technological applications, outcomes, or empirical evaluations within either elite-level sports training or educational sports contexts. Articles not meeting these explicit criteria, or lacking sufficient methodological rigor, were excluded. After this detailed assessment, a final sample of 45 high-quality articles was selected for comprehensive analysis.

The transparency and rigor of this systematic selection process, clearly outlined in the Figure 1 PRISMA flow diagram, ensures replicability and reliability of the findings, establishing a robust basis for understanding the practical applications and potential educational transfer of artificial intelligence technologies.

Figure 1. PRISMA Flow Diagram of the Systematic Literature Selection Process



Procedure

The procedural approach was carefully designed to ensure comprehensive coverage and methodological rigor, facilitating a clear exploration of practical AI technology applications and their adaptability to school sports contexts.

The selection process involved a two-step screening method performed by two independent reviewers to reduce selection bias and enhance reliability. Initially, titles and abstracts of articles were carefully examined for adherence to inclusion criteria, specifically focusing on practical applications and explicit relevance to elite sports and school sports contexts. Any discrepancies were resolved through consensus or consultation with a third reviewer.

Subsequently, full-text versions of the selected publications were subjected to rigorous evaluation. Articles were assessed on methodological rigor, explicit practical implementation of AI technologies, clearly documented outcomes, and relevance to the research objectives. Publications not meeting these specific criteria were excluded, ensuring inclusion of only methodologically robust and relevant literature.

Additionally, the study included a descriptive practical analysis of AI technologies currently implemented in elite sports contexts. This practical analysis focused on identifying essential functional components, evaluating practical usability, and assessing the potential adaptability of these technologies for integration into school sports settings. Specific attention was given to technological solutions that demonstrated feasibility, simplicity, affordability, and scalability within educational environments.

This carefully structured procedural approach ensures the replicability of the research process and significantly strengthens the validity and practical relevance of conclusions regarding the transferability of AI technologies from elite sports into educational sports contexts.

Risk of Bias Evaluation

In line with the PRISMA 2020 guidelines (Page et al., 2021), a structured risk of bias assessment was performed for all included studies. The evaluation focused on five key methodological criteria: study design, sample size justification, transparency of data collection, objectivity of outcome measures, and disclosure of funding/conflicts of interest. Each study was independently assessed by two reviewers and classified as presenting a low, moderate, or high risk of bias. Discrepancies were resolved through consensus. This systematic assessment provided an additional layer of methodological rigor and allowed for a more nuanced interpretation of the review findings.

Data analysis

Data analysis in this study involved a structured, descriptive approach to systematically organize and interpret findings extracted from selected publications. Initially, data were categorized into distinct thematic clusters relevant to the research objectives: biometric monitoring technologies, predictive analytics for injury prevention, personalized training solutions, tactical performance analysis, and educational technology integration.

Descriptive quantitative analysis was performed to summarize the frequency, distribution, and effectiveness of specific AI technologies reported in the literature. This analysis facilitated a clear identification of prevalent trends, common functionalities, and demonstrated outcomes within each thematic area. Additionally, the practical characteristics of each identified technology - such as simplicity of use, cost-effectiveness, and feasibility for implementation in educational contexts - were assessed qualitatively.

Comparative analysis was also conducted to evaluate similarities and differences among technological applications across elite sports and potential school sports contexts. This allowed the identification of specific technologies with high potential for successful adaptation and transfer to school-based physical education settings.

The descriptive and comparative methodological approach ensured clarity, replicability, and robustness of findings, providing a comprehensive and practical foundation for discussing the potential integration and effective use of AI technologies within school sports environments.

Results

The systematic analysis of selected publications revealed clear patterns and insights regarding the implementation of artificial intelligence (AI) technologies in elite sports and their potential applicability to school sports contexts. The findings are structured according to the predefined thematic clusters:

Biometric Monitoring Technologies

The analysis highlights the widespread use of wearable AI technologies for physiological monitoring and biomechanical analysis in elite sports, demonstrating potential relevance for educational contexts (Table 1). Parameters commonly monitored include heart rate variability, muscular fatigue, and biomechanical parameters such as running technique and gait analysis. Of particular interest for school sports is the capability of certain AI-enhanced wearable and video-based technologies to perform biomechanical analyses, such as assessing and correcting running technique in children who lack proper form or technique.

Table 1. AI-enhanced technologies existing in sports and transferable to school contexts

Technology	Biomechanical Analysis	Hydration Monitoring	Muscular Fatigue Monitoring	Heart Rate Variability	Cost Level	Ease of Implementation	Recommended Sports for School Context
Video-based analysis	High	No	Moderate (indirect)	No	Moderate-High	Moderate	Athletics, Gymnastics, Team sports
GPS-based wearables	Moderate	No	Moderate (indirect)	No	Moderate	High	Athletics, Team sports
Heart rate monitors	Low	Moderate (indirect)	Low (indirect)	High	Low	High	Athletics, Team sports
Inertial sensors	High	No	High (direct)	No	Moderate	Moderate	Athletics, Team sports
Hydration sensors	Low	High (direct)	No	No	Moderate	Moderate	All sports, endurance-based

The diverse range of AI-enhanced technologies outlined in Table 1 highlights not only their existing effectiveness in elite sports contexts but also their substantial potential for enhancing educational outcomes in school sports, particularly through the personalized monitoring and targeted improvement of students' physical performance and technical skills.

Predictive analytics for injury prevention

Analysis of the literature indicates a significant application of predictive analytics within elite sports, providing critical insights into injury prevention through the proactive management of training loads and athlete recovery. Such technologies hold substantial promise for adaptation in school sports, especially in helping physical education teachers and coaches to proactively identify and manage the risk of potential injuries among student-athletes, thus promoting safe participation and sustained engagement.

Specifically, machine learning algorithms, neural networks, and regression-based models are frequently utilized, each demonstrating varying degrees of prediction accuracy and application complexity (Table 2). For school settings, these predictive models can offer practical insights by analyzing simple datasets such as training frequency, intensity, and basic biometric information, enabling educators to tailor training programs according to students' individual capabilities and needs.

Table 2. Applicability of Predictive AI Models in Educational Sports Contexts

AI Model Type	Prediction Accuracy (%)	Suitable School Sports	Data Requirements	Real-Time Application	Implementation Feasibility
Machine Learning algorithms	85–92%	Football, Handball, Basketball, Voleyball	Moderate	High	Moderate
Neural Networks	88–94%	Athletics, Gymnastic, Team sports	High	Moderate	Moderate-Low
Regression-based models	78–86%		Low	Moderate	High

These predictive analytics tools, appropriately simplified for educational use, offer significant potential to enhance the safety and effectiveness of physical education programs, providing valuable support for personalized training management and injury prevention strategies in school environments.

Personalized training solutions

The analysis reveals substantial potential for AI-driven personalized training solutions to significantly enhance school-based physical education programs. AI algorithms currently utilized in elite sports contexts effectively adapt training regimens based on individualized biometric data, historical performance records, and real-time monitoring, thus optimizing athletes' physiological responses and performance outcomes.

In educational contexts, similar simplified AI-driven personalization models could be implemented to provide individualized training programs tailored to students' unique physical abilities, developmental stages, and fitness goals. For instance, machine learning algorithms can use accessible and easily collectable data such as age, physical condition, skill level, and activity preferences to develop personalized exercise routines. This approach would not only maximize each student's physical potential but also significantly increase motivation, engagement, and enjoyment of physical education classes.

Furthermore, pilot implementations within school settings have demonstrated promising outcomes, with personalized training plans leading to improved motor skills, higher levels of participation, and greater overall satisfaction among students. Consequently, the effective integration of simplified AI-driven personalization technologies in school sports contexts represents a valuable opportunity for enhancing both student performance and long-term health outcomes.

Table 3. AI-based Personalized Training Solutions and Their School Applicability

AI Solution Type	Data Required	Personalization Level	School Implementation Feasibility	Potential Benefits for Students
Machine learning-based adaptive training	Age, skill level, physical condition, training history	High (individualized routines)	Moderate	Enhanced motivation, tailored skill development
Real-time feedback systems	Biometric data, exercise performance parameters	Moderate to High	Moderate to Low	Immediate technique improvement, increased engagement
Gamified AI training systems	Preferences, skill level, performance outcomes	Moderate	High	Increased enjoyment, sustained participation

The AI-based solutions presented in Table 3 highlight feasible pathways for effectively integrating personalized training technologies into school physical education programs, potentially fostering greater student engagement, improved motor skills, and long-term commitment to physical activity.

Tactical performance analysis

Analysis of tactical performance using AI-driven video and computer vision technologies demonstrates significant potential for enhancing strategic understanding and decision-making in elite sports. These advanced systems provide detailed analyses of game situations, player positioning, movement patterns, and strategic effectiveness, enabling precise, data-driven adjustments.

Transferring simplified versions of these technologies to school sports settings could substantially benefit student learning and team performance. For example, AI-enhanced video analysis can help physical education teachers and coaches visualize and communicate tactical concepts more effectively, improving students' understanding of strategic gameplay. In addition, simplified AI-based tools could provide accessible analyses of student performance during games, facilitating immediate feedback on team dynamics, tactical decisions, and individual player contributions.

Implementing these AI-supported tactical analyses in educational contexts could lead to improved tactical awareness, teamwork, and decision-making skills among students, ultimately enhancing both educational outcomes and the competitive experience in school sports programs.

Table 4. AI-based Tactical Analysis Technologies and Their Applicability in School

AI Technology Type	Analytical Features	Data Complexity	Ease of Use for Schools	Educational Benefits
Video-based tactical analysis	Player positioning, team formations, movement patterns	Moderate to High	Moderate	Enhanced strategic understanding, improved teamwork

Real-time tactical feedback	Immediate game scenario analysis, decision suggestions	High	Moderate to Low	Improved decision-making, tactical adaptability
Post-game AI analysis software	Performance review, detailed tactical breakdowns	Moderate	High	Increased tactical awareness, clear learning outcomes

The tactical analysis technologies summarized in Table 4 provide practical and accessible tools that can significantly enrich tactical education within school sports programs, enhancing students' strategic understanding and fostering improved teamwork and decision-making skills.

Eductional technology integration

The analysis indicates that the direct integration of AI technologies into educational sports contexts, although currently limited, shows substantial potential. Pilot projects using AI-enhanced educational tools such as virtual reality (VR) platforms, interactive gamified environments, and intelligent tutoring systems have demonstrated considerable promise.

AI-driven VR technologies enable students to safely engage in immersive environments, practicing complex motor skills and tactical scenarios that might be challenging to replicate in traditional settings. These virtual platforms can significantly enhance students' skill acquisition, confidence, and motivation.

Interactive gamified environments powered by AI have also shown positive impacts on student engagement and participation levels. By providing instant feedback, personalized challenges, and motivating rewards, these AI-supported gamification tools encourage consistent and enthusiastic student participation in physical education activities.

Furthermore, intelligent tutoring systems using simplified AI algorithms can offer students personalized guidance, immediate performance feedback, and adaptive learning pathways based on individual progress. These systems not only improve motor skills and physical capabilities but also foster a more inclusive and supportive learning environment.

Overall, the integration of such AI-driven educational technologies into school sports programs could significantly enrich the educational experience, enhance student engagement, and improve physical education outcomes, representing a promising direction for future educational initiatives.

Table 5. AI-Enhanced Educational Technologies Applicable to School Sports

Educational Technology Type	Core Features	Complexity of Implementation	Student Engagement Level	Key Educational Outcomes
AI-enhanced Virtual Reality (VR)	Immersive motor skill training, scenario simulation	Moderate to High	High	Enhanced skill acquisition, increased confidence
Interactive AI-Gamified Platforms	Personalized challenges, real-time feedback, motivational rewards	Moderate	High	Increased motivation, sustained participation
Intelligent Tutoring Systems	Personalized feedback, adaptive skill development	Moderate	Moderate to High	Improved individual performance, inclusive learning

As highlighted in Table 5, the use of AI-enhanced educational technologies offers compelling benefits, potentially revolutionizing how students engage in physical education and supporting personalized learning experiences tailored to individual student needs and preferences.

Risk of Bias Assessment

The methodological quality and potential risk of bias of the included studies were carefully examined following the PRISMA 2021 guidelines (Page et al., 2021). Several key aspects were evaluated, including study design, transparency of data collection, reporting of outcomes, and potential conflicts of interest.

Most of the studies included in this review presented a moderate to low risk of bias, as they were peer-reviewed and provided sufficiently detailed descriptions of their methodologies. However, certain limitations were observed:

- Some articles lacked a clear description of sample size justification or control groups.
- A few studies relied heavily on self-reported measures of training outcomes, which may introduce subjectivity.

- In several cases, the funding source or potential conflicts of interest were not explicitly declared, creating uncertainty regarding neutrality.

Overall, while the majority of evidence supporting AI applications in sports can be considered reliable, these methodological weaknesses highlight the necessity of interpreting findings with caution, especially when considering the transferability of results to school sports contexts.

To provide a clearer overview, the main sources of potential bias identified across the included studies were summarized according to five key methodological criteria. Table 7 presents the distribution of studies rated as low, moderate, or high risk of bias for each criterion, highlighting the most frequent limitations encountered.

Table 6. Summary of Risk of Bias Across Included Studies

Criterion	Low Risk (n,%)	Moderate Risk (n,%)	High Risk (n,%)	Notes / Common Issues
Clear description of study design	35 (78%)	8 (18%)	2 (4%)	Some lacked detail on control groups
Adequate sample size justification	28 (62%)	10 (22%)	7 (16%)	Power analysis rarely reported
Transparency of data collection methods	33 (73%)	9 (20%)	3 (7%)	Occasional missing info on instruments
Objectivity of outcome measures	31 (69%)	11 (24%)	3 (7%)	Self-reported data in some studies
Disclosure of funding/conflicts of interest	26 (58%)	13 (29%)	6 (13%)	Several studies omitted funding details

Overall: The majority of included studies presented a low to moderate risk of bias. However, incomplete reporting on sample size, outcome objectivity, and funding transparency suggests that conclusions should be interpreted with caution.

Discussion

The findings of this systematic review highlight clear opportunities and practical pathways for integrating artificial intelligence (AI) technologies into school-based physical education. The distinct categories identified - biometric monitoring, predictive analytics, personalized training, tactical analysis, and educational technology integration - each offer specific advantages that align closely with educational goals and student developmental needs. Nevertheless, when interpreting these findings, it is also important to consider the potential methodological limitations and risk of bias within the included studies.

An important aspect emerging from this review is the presence of moderate risk of bias in some of the included studies. Although most research in elite sports demonstrated methodological rigor, occasional shortcomings—such as limited reporting transparency, lack of standardized assessment protocols, or insufficient disclosure of conflicts of interest—could affect the strength of conclusions. These observations are consistent with previous reviews in sports sciences that emphasized similar methodological vulnerabilities (e.g., Bartlett et al., 2022; MunozMacho et al., 2024; Olmos Gomez et al., 2025; Shekerbekova et al., 2023). From an educational transfer perspective, acknowledging these limitations is crucial. If the foundational studies on AI in elite sports contain biases, their direct applicability to school settings must be carefully evaluated and adapted. This reinforces the importance of implementing not only technological innovations but also rigorous monitoring frameworks and transparent evaluation practices in future school-based applications.

Biometric monitoring results underline that AI-enabled wearables and video technologies provide valuable biomechanical feedback, enabling physical education teachers to address and correct students' technical deficiencies, such as running form and posture. This aligns with current understandings emphasizing the role of immediate and precise feedback in motor learning and skill acquisition among young learners.

Predictive analytics findings illustrate that machine learning and other AI models possess strong potential for school-level adaptation, helping educators proactively manage training loads and prevent potential injuries. Such technologies offer immediate relevance in physical education programs, supporting safer participation and sustained physical activity engagement.

Results concerning personalized training solutions indicate that simplified AI-driven systems can effectively tailor exercise routines to individual student profiles, fostering increased motivation, active participation, and personal skill development. This approach resonates with contemporary educational principles advocating for differentiated learning and student-centered teaching methodologies.

The tactical analysis results highlight AI technologies' capacity to enhance strategic understanding and teamwork within school sports. Implementing accessible AI-based video and real-time analysis tools supports clearer tactical communication and improved student decision-making, fostering enhanced cognitive and cooperative skills critical for educational and athletic success.

Educational technology integration findings emphasize significant benefits associated with AI-supported gamified environments, virtual reality applications, and intelligent tutoring systems. These technologies demonstrably increase student engagement, provide personalized learning opportunities, and foster inclusive and motivating physical education environments.

Beyond immediate educational outcomes, the early adoption of AI technologies in physical education can significantly contribute to developing students' digital competencies. By interacting regularly with advanced technological tools, students become better prepared for future academic and professional environments, which increasingly demand digital fluency and adaptability.

The interdisciplinary potential of AI technologies in physical education also merits attention. Integrating these tools could facilitate valuable collaborative projects linking physical education with subjects like biology, physics, mathematics, and computer science. This interdisciplinary approach not only enriches learning experiences but also provides students with comprehensive insights into real-world applications of theoretical knowledge.

From an inclusion and accessibility perspective, AI technologies offer substantial opportunities to create equitable physical education environments. Customized training solutions and adaptive feedback mechanisms help address diverse student needs and abilities, ensuring that all students can actively and meaningfully participate. Such inclusive practices reinforce positive attitudes toward physical education and foster equitable learning conditions.

Despite the evident benefits, several practical challenges must be addressed for successful implementation. These include financial constraints, infrastructure limitations, and initial complexities related to technology use. Identifying cost-effective solutions, securing necessary funding, and developing user-friendly AI systems are critical factors for overcoming these challenges.

Finally, policymakers and educational stakeholders must play a proactive role by establishing clear educational policies, allocating appropriate resources, and fostering strategic partnerships with technology providers. Concrete steps, including dedicated investments, clear implementation guidelines, and regular evaluation mechanisms, will ensure that the integration of AI technologies into school-based physical education is both sustainable and impactful.

Conclusions

This systematic review demonstrated the significant potential and practicality of transferring artificial intelligence (AI) technologies, originally designed for elite sports, into educational contexts, specifically school-based physical education programs. The study achieved its objectives by clearly identifying and analyzing applicable AI solutions such as biometric monitoring, predictive analytics, personalized training solutions, tactical performance analysis, and educational technology integration.

The work contributed to the existing literature by highlighting specific ways these advanced technologies can positively impact educational outcomes, student engagement, and motor skill development. It also provided concrete evidence of the educational and developmental benefits of implementing AI-driven solutions within school sports contexts.

Furthermore, this research emphasized the practical considerations necessary for successful implementation, including addressing financial, infrastructural, and educational barriers. The necessity of teacher training and strategic policy initiatives was clearly established as crucial factors in achieving sustainable integration.

For future research, the study suggests a deeper exploration into specific implementation case studies within various school environments, detailed cost-benefit analyses, and longitudinal studies examining long-term impacts on students' physical and educational development. Additionally, developing and evaluating simplified, user-friendly AI tools tailored explicitly for educational use represents an important next step to further bridge the gap between elite sports innovations and practical school applications.

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