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The Role of Artificial Intelligence in Enhancing Physical Education Teaching and Sports Performance: A Systematic Review

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ABSTRACT

Artificial intelligence (AI) is increasingly embedded in school-based physical education (PE) and in elite and recreational sport, promising more individualized instruction, more objective skill assessment, and more precise performance and injury management. This paper presents a systematic narrative review synthesizing recent peer-reviewed literature (2014–2026) on AI applications across two connected domains: physical education pedagogy and sports performance analytics. Following a PRISMA-informed search and thematic synthesis of eighteen primary and review-level sources drawn from databases including Web of Science, Scopus, PubMed, IEEE Xplore, and ERIC, the review identifies four dominant application clusters: personalized and adaptive instruction, automated motor-skill assessment, wearable-sensor performance analytics, and AI-assisted injury-risk prediction. To integrate these findings, the paper proposes and explains an original conceptual framework, the AI–Physical Education Performance Enhancement Model (AI-PPEM), which links data acquisition, AI processing, pedagogical and athletic application, and measurable outcomes through a continuous feedback loop. The review also surveys documented challenges, including data privacy, algorithmic bias, teacher AI-literacy gaps, and limited external validation of predictive models, and outlines directions for future research and practice. The findings suggest that AI functions most effectively as an augmentative tool that extends, rather than replaces, the judgment of physical educators, coaches, and sports-medicine professionals.

KEYWORDS: *artificial intelligence; physical education; sports performance; machine learning; wearable sensors; injury prediction; systematic review.*

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1. INTRODUCTION

Physical education (PE) and competitive sport share a common practical challenge: instruction and training must respond to highly individual bodies, skill levels, and physiological states, yet they are typically delivered to groups under significant time and resource constraints. Over the past decade, artificial intelligence (AI) — encompassing machine learning (ML), deep learning, computer vision, and natural language processing — has moved from a peripheral curiosity in sport science to an active area of pedagogical and athletic innovation. Digitalization and intelligent technologies have become an explicit direction for the sports and education sectors, with AI positioned to participate in the formulation of teaching strategies, the tracking of instructional processes, and the evaluation of learning outcomes.

In parallel, elite and amateur sport have absorbed AI-enabled wearable sensors, motion-capture systems, and predictive analytics that convert raw biomechanical and physiological signals into actionable insight for coaches, athletes, and clinicians. Multi-sensor fusion systems that combine inertial measurement units, electromyography, and heart-rate monitoring are increasingly cloud-connected, enabling near real-time analysis of training load and movement quality. These parallel developments in classroom pedagogy and athletic performance science are rarely reviewed together, even though they rest on the same underlying technological stack — data capture, model inference, and feedback delivery — and are frequently used by the same institutions and personnel, particularly in university and school sport programs.

This paper addresses that gap by systematically reviewing literature published between 2014 and 2026 on AI in PE teaching and sports performance, and by proposing a single integrative conceptual model that explains how the two domains function through a shared underlying architecture. The specific objectives of the review are threefold: (1) to map the principal categories of AI application in PE instruction and in sports performance monitoring; (2) to synthesize these applications into one explanatory model of how AI transforms raw data into pedagogical and athletic outcomes; and (3) to identify the methodological, ethical, and practical limitations reported across the literature, together with priorities for future research.

2. Methodology

This review follows the general reporting logic of the PRISMA 2020 framework, adapted for a narrative synthesis of recent systematic reviews, scoping reviews, and empirical studies rather than a full quantitative meta-analysis. The search covered the period January 2014 to July 2026 across five databases: Web of Science, Scopus, PubMed/MEDLINE, IEEE Xplore, and ERIC, supplemented by Google Scholar for grey literature. Search strings combined the terms "artificial intelligence," "machine learning," "deep learning," or "computer vision" with "physical education," "sports performance," "athlete monitoring," or "injury prediction," joined using Boolean operators.

2.1. Eligibility Criteria

Records were included if they were peer-reviewed journal articles, indexed conference papers, or systematic/scoping reviews published in English; reported an application, evaluation, or synthesis of AI or ML methods in a PE, school sport, or athletic-performance context; and provided sufficient methodological detail to assess the nature of the AI application. Studies focused solely on general educational technology without an explicit AI/ML component, and non-peer-reviewed opinion pieces, were excluded.

2.2. Study Selection and Synthesis

Titles and abstracts were screened for topical relevance, followed by full-text review of candidate sources. The final synthesis draws on eighteen sources: primary empirical studies, systematic and scoping reviews, and narrative reviews spanning K-12 PE, higher education, and elite sport contexts (see References). Data were extracted on the AI technique used, the application domain (teaching or performance), reported outcomes, and stated limitations. Extracted data were then organized thematically, following the conventional approach used in recent PE-focused systematic reviews, and mapped onto the conceptual model presented in Section 3.

3. Conceptual Model: The AI–Physical Education Performance Enhancement Model (AI-PPEM)

A recurring observation across the reviewed literature is that AI applications in PE teaching and in sports performance, although discussed in separate bodies of literature, rely on structurally identical processes: data are captured from the learner or athlete, processed by an AI system, translated into a domain-specific application, and fed back to inform subsequent practice. To make this shared architecture explicit, this review proposes the AI–Physical Education Performance Enhancement Model (AI-PPEM), illustrated in Figure 1. The model is organized into four sequential layers connected by a continuous feedback loop, and is intended as an explanatory synthesis tool rather than a causal or statistically validated model.

Figure 1 depicts the AI-PPEM as a four-layer pipeline. Layer 1, Data Acquisition, captures the raw inputs available in modern PE and sport settings: wearable and biometric sensors (heart-rate, accelerometry, GPS), video and motion-capture streams processed through computer vision, learning-management-system and assessment records, and contextual or environmental data such as facility conditions and class composition. Layer 2, the AI Processing Core, is the analytical engine that converts these heterogeneous inputs into structured information; it draws on supervised and unsupervised machine learning for classification and pattern detection, deep-learning and computer-vision models for automated movement or form analysis, natural-language processing for feedback generation and conversational tutoring, and predictive analytics for forecasting outcomes such as injury risk or skill trajectory.

3.1. Explaining the Model Layers

Layer 3, Application Domains, is where the model branches into the two focal areas of this review. On the PE-teaching side, the processed data support personalized instruction that adapts task difficulty to a student's demonstrated competence, automated skill assessment that scores technique from video without requiring constant teacher observation, adaptive curricula that resequence content based on class-wide progress data, and engagement monitoring that flags disengaged or at-risk learners. On the sports-performance side, the same architecture supports biomechanical analysis that decomposes movement into joint angles and force patterns, training-load optimization that balances stimulus and recovery using accumulated wearable data, injury-risk prediction that flags athletes whose workload or movement signatures deviate from safe thresholds, and tactical or game analytics that extract patterns from match video.

Layer 4, Outcomes, represents the practical payoff of the pipeline: for PE, this includes improved learning outcomes, stronger motor-skill competence, greater inclusion of students with diverse needs, and higher motivation; for sport, it includes enhanced athletic performance, reduced injury incidence, and more efficient recovery planning. Critically, the model is not a one-directional pipeline. A continuous feedback loop, shown on the right of Figure 1, returns outcome data back into Layer 1, so that each teaching session or training cycle becomes a new data-generating event that refines subsequent AI processing — a property that mirrors how adaptive learning platforms and athlete-monitoring systems are described as improving with accumulated longitudinal data in the reviewed literature.

The explanatory value of the AI-PPEM is that it clarifies why the same technical infrastructure (sensors, computer vision, ML pipelines) can be marketed and studied as either an "EdTech" tool or a "SportsTech" tool: the divergence occurs only at Layer 3, where the same processed signal is routed toward a pedagogical or an athletic-performance objective. This has a direct practical implication for institutions such as university sport-science departments, which often run both PE-teacher training and competitive athletics programs: infrastructure investment in Layers 1 and 2 (sensors, cameras, computing capacity, staff data literacy) benefits both application domains simultaneously, whereas Layer 3 and Layer 4 decisions should remain domain-specific and led by qualified educators or sports-medicine professionals.

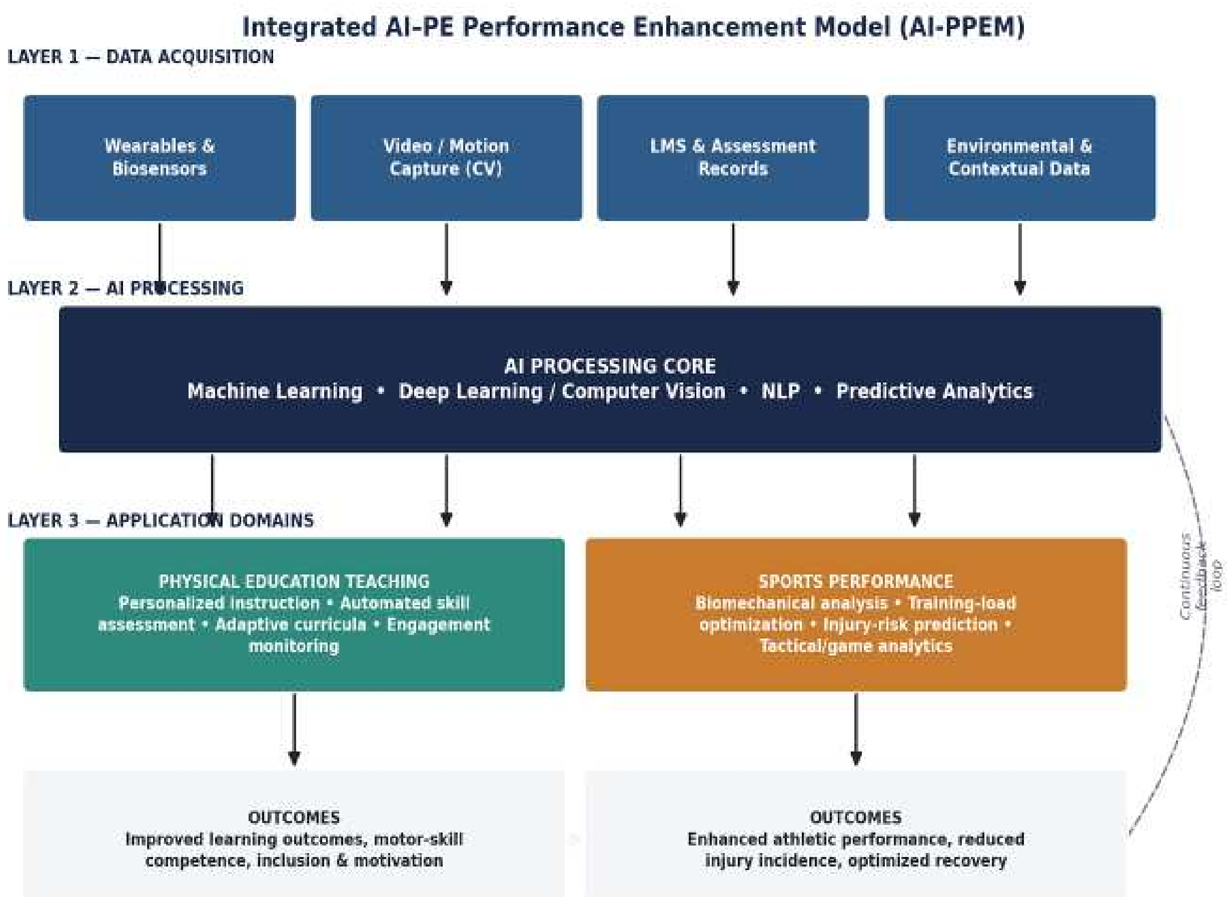

Figure 1. The AI–Physical Education Performance Enhancement Model (AI-PPEM), showing the four-layer pipeline from data acquisition to outcomes, with a continuous feedback loop linking outcomes back to data acquisition.

4. Thematic Findings

4.1. AI in Physical Education Teaching

Across the PE-focused literature, four recurring applications emerge. First, personalized and adaptive learning systems use AI to adjust task difficulty, pacing, or content sequencing to individual students, addressing the long-standing challenge of teaching heterogeneous ability groups within a single class period. Second, automated skill and motor-competence assessment applies computer vision and pose-estimation to score technique — for example in gymnastics, athletics, or fundamental movement skills — reducing the assessment burden on teachers and enabling more frequent, formative feedback. Third, AI-supported adapted and inclusive PE uses these same tools, often grounded in the Technology Acceptance Model, the Unified Theory of Acceptance and Use of Technology, and Universal Design for Learning, to extend individualized support to students with disabilities or special educational needs, partially compensating for large class sizes and limited one-to-one instructional time. Fourth, generative-AI and conversational tools are beginning to be used for feedback delivery and content creation, with recent work examining PE students' behavioral intention to use AI-generated content through extended acceptance-model frameworks.

Reviews of this literature consistently note that research remains concentrated at early technology-readiness levels, with many studies reporting small-scale pilots, higher-education samples, or proof-of-concept systems (for example, expert systems and virtual-reality-assisted teaching platforms for sports such as tennis and football) rather than large-scale, longitudinal classroom deployment. Teacher preparedness is repeatedly flagged as a bottleneck: PE teachers report limited AI literacy, and reviews call for structured professional-development pathways so that teachers can supervise, interpret, and pedagogically contextualize AI-generated recommendations rather than defer to them uncritically.

4.2. AI in Sports Performance

In athletic-performance contexts, the literature converges on wearable-sensor-driven analytics as the dominant application. Inertial measurement units, surface electromyography, heart-rate variability sensors, and GPS trackers are combined with machine-learning and deep-learning models — including convolutional neural networks, long short-term memory networks, and recurrent neural networks — to classify movement patterns and predict injury risk from workload and biomechanical data. Reported classification performance in some studies reaches 86–95% accuracy for injury-related classification tasks, and workload-based models have shown substantially elevated injury risk once acute-to-chronic workload ratios exceed established thresholds, reinforcing the value of continuous, individualized load monitoring over generic training templates.

Beyond injury prediction, AI-integrated wearables support training-load optimization and recovery planning, biomechanical motion analysis for technique refinement, and, in some elite programs, more ambitious applications such as digital-twin athlete modeling that combines three-dimensional biomechanical simulation with longitudinal physiological data to trial training scenarios virtually before they are applied to a real athlete. Scoping reviews of AI in sports biomechanics similarly report growing use of computer-vision-based motion analysis for both performance enhancement and injury prevention across a wide range of sports, alongside continued discussion of ethical considerations and translational gaps between research prototypes and field-ready tools.

Despite these advances, methodological quality remains uneven. Risk-of-bias assessments of injury-prediction studies using tools such as PROBAST have found that only a minority of studies demonstrate low overall risk of bias, with common weaknesses including small sample sizes, absence of external validation, and analytical limitations that constrain generalizability beyond the original study population. Authors of these reviews consistently caution that AI-derived risk scores should be treated as one input among several, complementing rather than replacing the expertise of coaches, athletic trainers, and sports-medicine clinicians.

5. Challenges and Limitations

Several cross-cutting challenges recur across both the PE-teaching and sports-performance literatures reviewed here:

- Data privacy and governance: continuous biometric and video data collection from students and athletes raises consent, storage, and data-protection concerns that reviews consistently identify as under-addressed in current policy frameworks.
- Algorithmic bias and validity: predictive models trained on narrow or non-representative samples (frequently university-aged or elite-cohort participants) may not generalize to younger students, recreational athletes, or diverse body types and ability levels.

- Limited external validation: risk-of-bias assessments of injury-prediction and skill-assessment models frequently identify small samples and an absence of prospective, external validation as a barrier to clinical or classroom adoption.
- Educator and coach AI-literacy gaps: both PE teachers and sport coaches report insufficient training to interpret AI outputs critically, creating a risk of over-reliance on system recommendations.
- Equity and access: schools and sports programs with limited budgets face unequal access to sensors, computing infrastructure, and technical support, risking a widening gap between well-resourced and under-resourced institutions.
- Preservation of the human and social dimension: reviews of adapted and inclusive PE specifically caution that AI support must be balanced against the motivational, social, and relational aspects of physical education and coaching, which are not easily captured by automated systems.

6. Future Directions

Building on the gaps identified above, the literature points to several priorities for future research and practice. Longitudinal, multi-site studies are needed to test whether short-term gains observed in pilot studies of personalized PE instruction and AI-assisted skill assessment translate into sustained learning and performance benefits over full academic years or competitive seasons. Standardization of data-collection protocols and reporting practices for wearable-sensor studies would improve comparability across the fragmented body of injury-prediction research. Explainable-AI approaches are increasingly called for so that teachers, coaches, and athletes can understand why a system has generated a particular recommendation, rather than treating AI outputs as opaque authority. Finally, several reviews recommend embedding structured AI-literacy training into PE-teacher and coaching-certification curricula, alongside clearer institutional policies on data protection, so that the human expertise represented in Layer 3 and Layer 4 of the AI-PPEM (Figure 1) remains firmly in control of how AI-generated insight is applied.

7. Conclusion

This review synthesized recent literature on AI applications in physical education teaching and sports performance and proposed the AI–Physical Education Performance Enhancement Model (AI-PPEM) as a single explanatory framework linking data acquisition, AI processing, domain-specific application, and outcomes through a continuous feedback loop. The evidence indicates that AI is already reshaping both fields through personalized instruction, automated assessment, wearable-sensor analytics, and predictive injury-risk modeling, with encouraging but methodologically uneven results. The most consistent message across the reviewed sources is that AI functions best as a decision-support tool that augments, rather than substitutes for, the professional judgment of physical educators, coaches, and sports-medicine practitioners. Realizing AI's potential in both classroom and competitive settings will depend less on further technical sophistication and more on addressing data governance, model validation, equitable access, and the AI-literacy of the human professionals who ultimately interpret and act on its outputs.

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