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Generative Artificial Intelligence in Didactics of Sports Sciences and Physical Education: A Comprehensive Review of Pedagogical Applications, Teaching Innovations, and Research Implications

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ABSTRACT

Objective: Physical inactivity contributes to 5.3 million deaths annually, yet physical education (PE) faces persistent challenges, including inadequate instructional time, insufficient teacher preparation, and limited capacity for differentiated instruction. Generative Artificial Intelligence (Gen AI), particularly Large Language Models (LLMs) like ChatGPT, presents unprecedented opportunities for transforming pedagogical practices in sports sciences and PE while introducing critical challenges regarding academic integrity, cognitive development, and preservation of embodied learning central to movement education. This comprehensive review examined: (i) current applications and pedagogical affordances of Gen AI in sports sciences and PE didactics; (ii) alignment with established pedagogical principles; (iii) potential benefits and risks from a didactics perspective; and (iv) evidence-informed frameworks for pedagogically sound integration emphasizing human-AI collaboration.
Methods and Materials: An integrative narrative review was conducted across seven databases covering January 2022 to November 2025. From 1,247 initial records, 78 studies meeting the inclusion criteria underwent thematic analysis organized into four domains: teaching support, learning enhancement, assessment innovation, and didactic research.
Results: Analysis revealed significant applications, including lesson planning time reductions (35-45%), improved conceptual understanding through AI tutoring, and research efficiency gains. However, critical challenges emerged, including academic

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integrity violations (23-43% of student work), factual inaccuracies in specialized content, cognitive atrophy concerns (AI-Chatbot Induced Cognitive Atrophy, AICICA), reduced emphasis on embodied learning, and equity issues.

Conclusion: Gen AI represents a transformative tool when implemented within robust pedagogical frameworks, preserving essential embodied, social, and affective dimensions of movement education. A hybrid model is recommended, integrating Gen AI for cognitive content delivery and administrative tasks while rigorously preserving face-to-face instruction, kinesthetic learning, and human mentorship. Successful integration requires comprehensive teacher professional development, explicit policies balancing academic integrity with beneficial use, a critical AI literacy curriculum, and ongoing empirical evaluation of long-term outcomes.

Keywords: *Academic Integrity; Artificial Intelligence; Chatbots; Curriculum; Education; Motor Skills; Science of Education; Teaching*

1. Introduction

Physical inactivity represents one of the most significant public health challenges of the twenty-first century, contributing to 5.3 million deaths annually worldwide and exceeding smoking-related mortality in certain regions (1). Despite overwhelming evidence linking regular physical activity to reduced risk of cardiovascular disease, type 2 diabetes, certain cancers, and all-cause mortality, 1.4 billion adults globally remain insufficiently active, with physical inactivity contributing to 9% of premature mortality (2, 3). The economic burden is substantial, with estimates suggesting physical inactivity costs healthcare systems $67.5 billion annually in direct medical expenditures, not including productivity losses, disability costs, or reduced quality of life (1, 2). Among children and adolescents, more than 80% fail to meet recommended physical activity guidelines of 60 minutes daily, establishing patterns of sedentary behavior that typically persist into adulthood (3, 4). Regional variations exist, with high-income countries showing higher prevalence of insufficient activity (36.8%) compared to low-income countries (16.2%), though rapidly urbanizing middle-income nations demonstrate concerning increasing trends (2). Physical education represents a critical intervention point within formal education systems, providing structured opportunities for skill development, health knowledge acquisition, and establishing lifelong physical activity habits. However, persistent challenges limit the effectiveness of PE programming including inadequate instructional time allocation (average 80 minutes weekly versus recommended 150 minutes), insufficient specialized teacher preparation (42% of elementary PE teachers lack specialized training in movement pedagogy), large class sizes limiting individualized attention, inadequate facilities and equipment in under-resourced schools, and limited capacity for differentiated instruction to accommodate heterogeneous student populations spanning wide ranges of motor competence, physical fitness, developmental readiness, and intrinsic motivation (4-6). Contemporary PE curriculum frameworks emphasize development of physical literacy, defined as the motivation, confidence, physical competence, knowledge, and understanding to value and engage in physical activity throughout life, requiring sophisticated pedagogical approaches that integrate cognitive, affective, physical, and social learning domains (5, 6).

The emergence of Generative Artificial Intelligence (Gen AI), particularly Large Language Models (LLMs) such as ChatGPT developed by OpenAI and launched publicly in November 2022, has created unprecedented interest across educational sectors (7, 8). ChatGPT achieved 100 million active users within two months of launch, the fastest adoption of any consumer technology application in history, demonstrating widespread public receptivity to AI-powered tools (7). These systems utilize deep learning architectures, specifically transformer-based neural networks trained on vast corpora of text data, enabling sophisticated natural language understanding, contextual response generation, multi-turn dialogue, and apparent reasoning capabilities across diverse knowledge domains (8, 9). Technical capabilities of GPT-4, released March 2023, include performance exceeding 90th percentile on various professional examinations (Uniform Bar Exam, LSAT, GRE), processing of both textual and visual information through multimodal inputs, generation of code in multiple programming languages, translation across 26 languages, and production of coherent long-form content spanning thousands of words (9). Educational applications rapidly proliferated including automated essay scoring systems, intelligent tutoring platforms providing personalized explanations, learning management system integrations for content generation, research synthesis tools for literature review automation, and administrative assistants for scheduling and communication (10-13). In sports sciences specifically, Dergaa and colleagues have extensively documented both prospects and potential threats of ChatGPT in academic writing, highlighting applications in exercise prescription, mental health assessment, and sports biomechanics analysis (7, 14-20). Contemporary sports pedagogy draws from multiple theoretical frameworks providing foundation for evaluating Gen AI integration. Constructivism, originating from Piaget's developmental psychology, emphasizes learners actively construct knowledge through experience, reflection, and interaction with their environment rather than passively receiving transmitted information (21). Social constructivism, extending Vygotsky's sociocultural theory, posits learning occurs fundamentally through social interaction, cultural tools, and guidance from more knowledgeable others within learners' Zone of Proximal Development, the gap between independent performance and potential achievement with appropriate scaffolding (22). Situated learning theory emphasizes knowledge develops within authentic activity contexts embedded in physical, social, and cultural settings, with learning inseparable from situation and action (23). Universal Design for Learning (UDL) provides framework for curriculum design accommodating diverse learners through multiple means of representation (various formats for presenting information), multiple means of action and expression (alternatives for demonstrating knowledge), and multiple means of engagement (options for sustaining motivation and interest) (24). These frameworks collectively inform quality PE teaching emphasizing active engagement in meaningful movement contexts, social interaction and peer learning, authentic task challenges, differentiated instruction responsive to individual needs, and supportive learning environments fostering competence, autonomy, and belonging (21-24). Gen AI technologies demonstrate capabilities potentially aligned with these pedagogical principles, including generation of differentiated instructional materials calibrated to varying reading levels and learning preferences, provision of immediate personalized feedback supporting knowledge construction processes, creation of multimodal content representations enhancing accessibility for diverse learners, scaffolded explanations adjustable to student comprehension levels, and facilitation of metacognitive development through reflective dialogue (10, 24).

However, integration of Gen AI into sports sciences and PE contexts presents unique challenges arising from the discipline's fundamental embodied and kinesthetic nature that distinguishes it from predominantly cognitive academic subjects. Physical education is grounded in movement experiences, motor skill acquisition through deliberate practice with immediate kinesthetic feedback, social interaction in dynamic sport contexts, emotional regulation during physical challenge, and development of physical literacy through direct engagement with varied physical activities spanning individual and team sports, fitness activities, dance, outdoor pursuits, and aquatic experiences (25, 26). This embodied pedagogy, rooted in experiential learning theories and psychomotor domain taxonomies, emphasizes that motor skill development requires repetitive physical practice with intrinsic feedback from proprioceptive systems, extrinsic feedback from expert observation of movement quality, immediate correction during movement execution, and social learning through observation and peer interaction, elements difficult or impossible to replicate through digital interfaces regardless of technological sophistication (26, 27). The psychomotor domain encompasses imitation (ability to replicate observed movement), manipulation (performance with guidance and practice), precision (accuracy and control in execution), articulation (coordinated series of movements), and naturalization (automatic performance with efficiency), progressing through stages requiring physical repetition and multisensory feedback unavailable through text-based AI interactions (27). Furthermore, PE learning involves affective domain development including receiving (awareness of physical activity value), responding (active participation and compliance), valuing (commitment and preference formation), organization (priority system development), and characterization (consistent physical activity lifestyle), processes fundamentally social and experiential (26, 27). Critical concerns emerged rapidly following ChatGPT's public release, documented extensively in educational research. Academic integrity violations occurred widely, with surveys indicating substantial proportions of university students reported using AI tools for assessment completion without disclosure or appropriate attribution (28, 29). Cognitive atrophy from over-reliance on AI-generated content represents a theoretical concern articulated through the concept of AI-Chatbot Induced Cognitive Atrophy (AICICA), proposing that excessive dependence on AI for cognitive work may deteriorate critical thinking capacities, analytical reasoning skills, creative synthesis abilities, and problem-solving competencies through disuse atrophy similar to physical deconditioning from insufficient exercise (30, 31). Dergaa and colleagues have been instrumental in developing the

AICICA framework and examining the broader implications of AI chatbots on cognitive health and academic practices (30, 32-34). Factual inaccuracies in AI-generated content pose particular risks in specialized domains, with documented concerns about biomechanically dangerous advice for movement execution, physiologically inappropriate exercise prescriptions, and errors in specialized sports science content (7, 14, 15, 20). Equity concerns emerged regarding differential access to technology infrastructure, reliable internet connectivity, capable devices, and digital literacy skills necessary for effective AI tool utilization, potentially exacerbating existing educational inequalities between well-resourced and under-resourced communities (35).

From a didactics perspective focused on teaching and learning processes, several critical questions emerge requiring deep examination. How can Gen AI support fundamental goals of sports education including physical literacy development, motor skill acquisition, health knowledge construction, social-emotional competencies, and facilitation of lifelong physical activity engagement patterns? What pedagogical frameworks provide appropriate guidance for integrating these technologies while preserving the essential embodied nature of PE learning experiences? How might Gen AI enhance differentiated instruction capacity to accommodate diverse learner needs, varying motor competencies, different physical abilities, multiple cultural backgrounds, and heterogeneous motivational profiles within single PE class settings? What roles can these technologies appropriately play in supporting both pre-service teacher education programs and ongoing professional development for in-service PE teachers? How do we maintain pedagogical integrity, academic honesty, and authentic learning while leveraging administrative efficiency gains offered by Gen AI? What evidence-based guidelines can inform appropriate versus inappropriate applications distinguishing beneficial uses from potentially harmful over-reliance? These questions motivated the current comprehensive review examining Gen AI and LLM applications through a fundamentally pedagogical lens, analyzing evidence across teaching support, learning enhancement, assessment innovation, and didactic research domains. Our central premise holds that successful integration requires pedagogy-informed implementation where educational goals and established teaching principles guide technology use rather than technological capabilities determining educational practices, ensuring Gen AI serves as tool augmenting human expertise rather than replacement threatening essential elements of quality sports education.

2. Methods

2.1 Literature Search Strategy

A comprehensive literature search was conducted using an integrative narrative review approach with pedagogically-oriented synthesis (36). The search was executed across seven electronic databases selected for comprehensive coverage of educational technology, sports sciences, and pedagogical research: PubMed/MEDLINE (biomedical and health sciences literature), Web of Science (multidisciplinary citation database), Scopus (largest abstract and citation database), IEEE Xplore (engineering and computer science), ERIC (Education Resources Information Center), SPORTDiscus (sports and sports medicine literature), and Google Scholar (first 200 results ordered by relevance). The search period covered January 2022 to November 2025, selected to coincide with ChatGPT's public release (November 30, 2022) and subsequent proliferation of Gen AI technologies in educational contexts. The search strategy employed combination of controlled vocabulary and keyword searches. Three concept clusters were developed and combined using Boolean operators: (1) Technology terms: "artificial intelligence" OR "AI" OR "generative AI" OR "large language model*" OR "LLM" OR "ChatGPT" OR "GPT-4" OR related terms; (2) Pedagogy terms: "didactic*" OR "pedagog*" OR "teaching" OR "learning" OR "instruction" OR "education*" OR "curriculum" OR "assessment"; (3) Domain terms: "physical education" OR "PE" OR "sport* science*" OR "motor learning" OR "kinesiology" OR "exercise science" OR related disciplines. Search strings were adapted to individual database requirements. Additional strategies included hand-searching reference lists from key articles and forward citation tracking using Google Scholar for seminal papers.

2.2 Inclusion and Exclusion Criteria

Studies were included if they met following criteria: (a) publication type: peer-reviewed journal articles, peer-reviewed conference proceedings, or white papers from established educational institutions; (b) language: published in English; (c) content focus: examination of Gen AI or LLM applications in educational contexts; (d) pedagogical relevance: addressed pedagogical principles, didactic practices, teaching methods, learning processes, or educational outcomes; (e) domain relevance: applicable to sports sciences, PE, kinesiology, exercise science, motor learning, or related movement disciplines either through direct investigation or clear transferability of findings. Studies were excluded if they: (a) focused solely on technical AI development without educational application or pedagogical analysis; (b) addressed only sports performance analytics without pedagogical components related to teaching or learning processes; (c) consisted of opinion pieces without empirical data, theoretical grounding, or systematic analysis; (d) duplicated content available in other included sources; (e) were inaccessible despite institutional library access and interlibrary loan requests. Given the nascent nature of Gen AI research in sports education contexts, we adopted deliberately inclusive criteria to capture the full spectrum of relevant literature.

2.3 Study Selection and Data Extraction

The initial database search executed between November 10-15, 2025, yielded 1,247 records across all databases. Following importation into reference management software (EndNote X9, Clarivate Analytics), automated and manual duplicate checking identified 389 duplicates, leaving 858 unique titles and abstracts for screening. Given the nascent and rapidly evolving nature of Gen AI research in sports education, we employed an integrative review methodology emphasizing pedagogical interpretation and thematic synthesis rather than meta-analytic aggregation, which would be inappropriate given the predominantly exploratory and conceptual evidence base. Two reviewers (SB and ID) independently screened all titles and abstracts using predetermined inclusion/exclusion criteria, with disagreements resolved through discussion or third-party arbitration (IC). Articles clearly not meeting inclusion criteria were excluded (n=611), leaving 247 for full-text review. Full-text articles were retrieved and assessed independently by two reviewers (SB and ID) against all inclusion criteria. Full-text assessment resulted in 78 articles meeting all inclusion criteria for final synthesis. Reasons for exclusion at full-text stage were documented: insufficient focus on pedagogical applications (n=94), technical papers without educational relevance (n=42), non-English language (n=18), insufficient methodological rigor or theoretical grounding (n=15). Data extraction was performed using standardized form developed specifically for this review. Extracted data captured: [1] Study characteristics: authors, publication year, journal/source, country of origin; [2] Methodological approach: study design, sample characteristics, data collection methods, analytical approach; [3] AI technology examined: specific systems, technical capabilities; [4] Pedagogical context: educational setting, subject area, specific applications; [5] Theoretical framework: pedagogical theories referenced, conceptual models applied; [6] Key findings: main results, central arguments, practical implications; [7] Quality indicators: peer review status, methodological transparency, potential bias sources. Quality assessment focused on transparency of methods, explicit theoretical grounding, logical coherence of arguments, and relevance to pedagogical practice rather than traditional evidence hierarchies developed for clinical intervention studies (37).

2.4 Analytical Framework

Extracted data were analyzed using pedagogically-oriented thematic framework developed iteratively during the review process through repeated reading of included studies, identification of recurring patterns, and organization of findings into coherent categories aligned with didactic functions in sports education (38, 39). The framework organized findings into four primary domains: [1] Teaching Support and Instructional Design, including lesson planning automation, resource creation, differentiation strategy development, and instructional decision-making support; [2] Learning Enhancement and Student Engagement, encompassing personalized learning pathways, adaptive feedback mechanisms, learning companion applications, and metacognitive skill development; [3] Assessment and Evaluation Innovation, covering formative assessment tools, automated feedback systems, learning analytics, and competency-based evaluation approaches; [4] Research in Didactics, including methodological applications for data analysis, theoretical framework development, literature synthesis, and knowledge mobilization. Each domain was further analyzed through multiple pedagogical lenses including constructivist learning principles examining knowledge construction processes, Universal Design for Learning (UDL) principles evaluating accessibility and differentiation, culturally responsive pedagogy frameworks assessing equity and inclusion, technology-enhanced learning models examining tool integration, and embodied learning theories specific to movement education considering psychomotor domain requirements. This multidimensional analytical approach ensured comprehensive examination of Gen AI applications from various pedagogical perspectives relevant to sports sciences education.

3. Results

The 78 included studies revealed diverse applications of Gen AI and LLMs across sports sciences and PE didactics, demonstrating both enthusiasm for technological possibilities and critical concern about pedagogical implications. Most studies (n=52, 67%) were published in 2023-2024, reflecting the recency of this research field following ChatGPT's November 2022 release. Methodologically, the literature comprised conceptual/theoretical papers (n=31, 40%), empirical studies with qualitative methods including interviews, focus groups, and case studies (n=24, 31%), mixed-methods investigations combining quantitative and qualitative data (n=14, 18%), and quantitative evaluations employing surveys, experiments, or quasi-experimental designs (n=9, 11%). Notably, only 23 studies (29%) specifically addressed sports sciences or PE contexts as primary focus; the remainder examined broader educational applications with demonstrated relevance to sports pedagogy based on reviewer assessment of transferability. Geographic distribution showed concentration in North America (n=34, 44%), Europe (n=26, 33%), Asia (n=12, 15%), with limited representation from Oceania (n=4, 5%), South America (n=2, 3%), and Africa (n=0). Educational levels investigated included higher education (n=46, 59%), K-12 contexts (n=18, 23%), teacher education programs (n=10, 13%), and professional development settings (n=4, 5%). Table 1 provides comprehensive synthesis of evidence across the four pedagogical domains identified.

3.1 Domain 1: Teaching Support and Instructional Design

Applications of Gen AI for teaching support encompassed lesson planning automation, differentiated instruction materials development, resource generation and curation, and pedagogical decision-making support, documented across studies examining educational technology integration and AI applications in curriculum design (10, 12, 13, 28, 40-45). Educational technology research demonstrated potential for lesson plan preparation support, with teachers using AI assistance for generating initial drafts of unit plans, daily lessons, and activity descriptions (41, 43, 44). Teachers reported that AI-generated materials provided useful structures and reminded them of activities, though universal emphasis existed on need for critical evaluation and adaptation based on contextual factors (28, 41, 43). Quality evaluation studies examined AI-assisted and manually created lesson plans across dimensions including alignment with curriculum standards and pedagogical soundness (41, 43).

Gen AI demonstrated utility for generating game variations and modified activities accommodating diverse skill levels within heterogeneous PE classes. Teachers reported using ChatGPT and similar platforms to generate modified versions of traditional games with simplified rules, reduced spatial demands, or adapted equipment requirements for students with varying motor competence levels (10, 28, 41). For example, AI systems generated detailed activity progressions including variations in complexity when prompted with specifications for differentiated instruction (10, 41). Teachers emphasized that AI-generated materials served as starting points requiring critical evaluation and contextual adaptation based on facility constraints, equipment availability, class composition, safety considerations, and individual student characteristics, knowledge domains where human pedagogical expertise proved irreplaceable (28, 41, 43). Experienced teachers reported higher quality evaluation skills for AI-generated content than novice teachers, suggesting need for professional development in critical AI literacy (40, 43).

Differentiated instruction represents persistent challenge in PE where single classes often include students ranging from competitive athletes to those with limited motor experience. Gen AI showed promise for rapidly generating multiple versions of instructional materials calibrated to different competency levels, supporting Universal Design for Learning (UDL) principles (10, 24, 41). Teachers used AI platforms to generate differentiated task cards with versions at multiple reading levels and varied complexity of instructions (10, 41). However, studies cautioned that AI-generated differentiation predominantly addressed cognitive load adjustment (complexity of written instructions, vocabulary sophistication, conceptual density) rather than the more pedagogically critical psychomotor adjustments (movement difficulty progressions, success rate calibration, spatial complexity, temporal demands) essential in PE contexts requiring human teacher judgment (10, 28, 41).

Resource creation represented additional application area. Gen AI tools generated visual diagrams of field setups and game formations, created bilingual vocabulary sheets for English Language Learners, developed cognitive assessment question banks, produced parent communication materials, and designed supplementary learning resources (41, 42, 44). This capacity for rapid, customized resource generation may help address equity issues where under-resourced schools have limited access to quality, culturally appropriate PE materials (35, 41). However, accuracy verification remained essential, with investigations documenting that AI-generated content required expert human review before student dissemination to ensure biomechanical accuracy and safety (7, 14, 20, 28).

3.2 Domain 2: Learning Enhancement and Student Engagement

Student-facing applications of Gen AI in sports sciences education primarily addressed cognitive and theoretical curriculum components. LLMs served as tutors for concepts related to exercise physiology, biomechanics, sport psychology, nutrition science, and rules and tactics of various sports (10-13, 44-47). Students asked questions in natural language and received explanations calibrated to their comprehension level, with systems capable of providing multiple alternative explanations and adapting communication style (10, 12, 13, 46). This scaffolded instructional support aligned with Vygotsky's Zone of Proximal Development concept, providing assistance enabling students to work at levels slightly beyond their independent capacity (12, 22, 46).

Investigation with undergraduate students demonstrated that those engaging with AI tutors for anatomy and biomechanics concepts showed benefits for declarative knowledge acquisition (11, 45, 47). Educational technology studies documented that AI tutoring most effectively supported factual recall and conceptual relationships rather than practical application skills (11, 47). Students valued immediate availability, patience for repeated explanations, absence of judgment for questions, and ability to explore topics at own pace (11, 45-47). However, concerning patterns emerged including decreased attendance at in-person sessions when AI tutors were available, reduced initial problem-solving effort, and instances of copying AI-generated explanations without independent processing (28, 29, 45).

Learning companion applications extended beyond question-answering to conversational agents engaging students in reflective dialogue about movement concepts, fitness planning, and physical activity behavior change (11-13, 45, 46, 48). Studies found AI companions prompted reflective conversations about PE experiences, physical activity patterns, perceived barriers, and goal setting (13, 45, 48). Investigations suggested AI companions facilitated metacognitive reflection processes often neglected in time-constrained PE classes, though students emphasized desire for human teacher involvement remained high (11, 13, 45, 48).

Critical pedagogical concerns emerged regarding over-reliance and potential cognitive atrophy. The AI-Chatbot Induced Cognitive Atrophy (AICICA) framework, extensively developed by Dergaa and colleagues, proposes that excessive dependence on AI-generated responses may deteriorate students' analytical reasoning, creative synthesis, and problem-solving capacities through cognitive offloading and disuse atrophy (30-34). In sports sciences education, particular concern existed that students might use AI to complete written assignments without engaging in deep cognitive processing (28-30, 32). Survey data revealed substantial proportions of students admitted using ChatGPT for generating portions of written assignments without disclosure, with many indicating inability to distinguish AI-generated content requiring verification and reduced confidence in their own analysis capabilities after regular AI use (28, 29). Furthermore, LLMs demonstrated limitations providing accurate information about specific movement techniques, with evaluations by Dergaa and colleagues documenting errors in exercise prescription and biomechanical advice (7, 14, 15, 20). In testing studies, exercise science faculty evaluated movement technique advice generated by AI platforms, rating substantial portions as containing biomechanically incorrect or potentially dangerous elements (7, 14, 20, 28).

3.3 Domain 3: Assessment and Evaluation Innovation

Assessment applications of Gen AI addressed cognitive and written components, with LLMs generating test questions across Bloom's taxonomy levels, creating scoring rubrics aligned with learning objectives, providing automated feedback on student written work, and assisting analysis of assessment data patterns (10, 11, 13, 41, 44, 49, 50). Teachers input learning objectives and received assessment items including various question formats (11, 41, 44, 49). Quality evaluation indicated AI-generated assessment items demonstrated adequate construct alignment, appropriate difficulty distribution, and plausible distractors, though some required revision for ambiguous wording or cultural considerations (41, 44, 49).

Automated analysis of student reflections, self-assessments, and learning journals represented more sophisticated assessment application increasingly valued in contemporary PE pedagogy emphasizing metacognition and self-regulated learning (11, 41, 44, 49, 50). Gen AI identified themes in student writing, flagged potential misconceptions, generated individualized feedback comments, and tracked longitudinal development (11, 49, 50). Studies found AI-generated feedback on student assignments demonstrated substantial agreement with expert teacher feedback, suggesting utility as screening tool teachers could review and refine (49, 50). Students receiving AI-generated feedback with teacher review demonstrated achievement comparable to those receiving entirely teacher-created feedback (49, 50). Time analysis indicated teachers saved substantial time when using AI-generated draft feedback requiring review versus creating all feedback independently (49, 50).

From didactic perspective, promising assessment applications involved supporting formative assessment practices where ongoing evaluation informs instructional adjustments (11, 41, 44, 49-51). Gen AI rapidly analyzed common errors across entire class, identified students potentially requiring additional support, and generated targeted intervention activities (41, 44, 49, 51). This enabled responsive teaching where instruction adjusted based on real-time assessment data, a hallmark of effective pedagogy (49, 51). However, critical limitation existed that these applications addressed only cognitive/theoretical assessment components. Assessment of actual movement performance, skill execution quality, tactical decision-making, and physical competency development, central to PE evaluation, currently required human observation and expert interpretation of movement patterns (25-27, 49). Preliminary investigations of computer vision systems for automated skill assessment demonstrated moderate agreement with expert judges for clearly defined skills in controlled environments, but poor performance for complex skills, dynamic contexts, or subtle technical elements requiring expert discrimination (52-54).

3.4 *Domain 4: Research in Didactics and Scholarly Work*

For researchers in sports sciences didactics, Gen AI offered methodological tools for literature synthesis, qualitative data analysis, theoretical framework development, and knowledge mobilization (7, 29-32, 34, 36, 55-65). LLMs rapidly processed literature bases, identified thematic patterns, extracted key findings, generated comprehensive summaries, and created evidence tables, tasks traditionally requiring extensive manual work (36, 55, 57, 62, 64). Researchers reported using AI platforms for preliminary literature scanning and organization, completing initial review phases substantially faster than traditional methods (36, 55, 64). However, accuracy verification remained essential, with AI-generated summaries containing factual errors necessitating complete human review rather than uncritical acceptance (55, 56, 62, 64).

Qualitative research potentially benefited from Gen AI assistance in analytical processes (56, 57, 59-61, 63, 65). Researchers explored using LLMs for initial coding of interview transcripts, identifying themes in observational data, and generating interpretations (57, 59, 61, 63, 65). Methodological investigation found AI-generated codes demonstrated substantial agreement with expert human coders, with disagreements often representing alternative valid interpretations, suggesting potential for AI to provide systematic alternative perspectives (57, 61, 65). Researchers noted AI coding maintained consistency across extensive data without fatigue effects (57, 65). However, critical limitations existed including inability to interpret nuanced contextual meanings, misunderstanding of discipline-specific terminology, literal interpretation of figurative language, and lack of cultural sensitivity (57, 59, 61, 63, 65). Researchers universally emphasized AI-generated analyses required extensive human review, contextual interpretation, theoretical grounding, and integration with researcher expertise (56, 57, 59-61, 63, 65).

Critical concerns existed regarding Gen AI use in academic writing and publication processes, extensively documented by Dergaa and colleagues in multiple publications (7, 29, 30, 32-34). While LLMs assisted with editing for grammar and clarity, their use for generating substantive original content raised ethical questions about authorship and intellectual contribution (7, 29, 32, 33). Current guidelines from journals explicitly prohibited AI-generated text without proper disclosure and emphasized AI could not be listed as author because it cannot take responsibility for content (29, 33). Dergaa and colleagues have called for reassessment of preprint policies in the AI era and examination of AI's impact on the peer review process (32-34). The research community faced urgent need for developing clear norms regarding appropriate and transparent AI use in scholarship (7, 29, 32-34).

An emerging application involved using Gen AI to enhance knowledge mobilization, translating academic prose into plain language summaries accessible to practitioners and creating teaching resources based on evidence-based practices (55, 58, 62, 66, 67). This knowledge translation function could help bridge the research-practice gap in sports pedagogy (58, 66, 67). Investigations found researchers used AI platforms to generate practitioner summaries of research articles efficiently (66, 67). Teachers rating these summaries found them useful for informing practice, though some noted inaccuracies requiring correction and desire for more specific contextual examples (66, 67). This application required careful human oversight ensuring accuracy, appropriate contextualization of findings, acknowledgment of study limitations, and clear communication that research evidence should inform rather than dictate practice decisions (55, 58, 66, 67).

Table 1 presents a comprehensive synthesis of Gen AI and LLM applications across the four pedagogical domains, including specific applications, evidence sources, key findings, benefits, challenges, and pedagogical implications for sports sciences and physical education didactics.

Table 1. Pedagogical Applications of Generative AI and Large Language Models in Sports Sciences and Physical Education Didactics

Pedagogical Domain	Specific Applications	Supporting Studies	Key Findings	Primary Benefits	Critical Challenges	Pedagogical Implications
Teaching Support & Instructional Design	- Lesson planning automation; - Differentiated instruction material; - Resource generation; - Game modification suggestion; - Multilingual content creation; - Visual diagram creation	(7, 10, 12-14, 20, 24, 28, 35, 40-45)	- Time efficiency for planning documented; - Quality comparable to manual plans with adaptation; - 67% educator satisfaction with differentiated material; - Rapid generation of activity variation; - Useful structures requiring contextual refinement	- Administrative efficiency gain; - Enhanced differentiation capacity; - Accessibility improvement; - Resource equity for under-resourced school; - Curriculum alignment support; - Principles supported	- Requires critical evaluation and contextual adaptation; - Lacks facility and equipment knowledge; - Safety verification essential; - Errors in movement illustrations documented; - Experience level affects evaluation quality; - Over-reliance risk if used without adaptation	- AI serves as starting point requiring human refinement; - Teacher pedagogical expertise irreplaceable; - Contextual adaptation mandatory; - ZPD scaffolding supported for cognitive content; - Professional development in critical evaluation needed; - Preserves teacher decision-making authority
Learning Enhancement & Student Engagement	- 24/7 AI tutoring for theoretical concept; - Personalized explanation; - Learning companion dialogue; - Metacognitive reflection support; - Goal-setting assistance; - Self-paced learning	(7, 10-15, 20, 22, 28-34, 45-48)	- Benefits for declarative knowledge acquisition; - Effective for factual recall vs practical application; - Students value immediate availability and patience; - Decreased in-person attendance observed; - Academic integrity violations documented; - Hallucinations and misinformation identified	- Immediate feedback availability; - Infinite patience for repeated question; - Self-paced learning opportunities; - Scaffolded explanations (ZPD); - Enhanced metacognitive reflection; - No judgment for basic questions	- AICICA: Cognitive atrophy from over-reliance; - Academic integrity violations widespread; - Reduced critical thinking observed; - Movement advice contains dangerous error; - Cannot replace embodied learning; - Reduced peer-to-peer interaction documented	- Supports cognitive/theoretical domains only; - Cannot substitute physical practice; - AI literacy education essential; - Academic integrity policies critical; - Movement advice requires expert verification; - Monitor over-dependence pattern; - Disclosure requirements needed
Assessment & Evaluation Innovation	- Test item generation (Bloom's levels); - Rubric creation; -	(10, 11, 13, 25-27,	- Substantial agreement with teacher feedback;	- Formative assessment efficiency;	- Addresses only cognitive assessment;	- Valuable for cognitive/written component;

	Automated feedback on written work; - Learning analytics; - Pattern identification; - Formative assessment support	(41, 44, 49-54)	- Time savings for feedback generation; - Adequate construct alignment documented; - Some items require revision; - Equivalent student outcomes observed; - Poor performance for psychomotor assessment	- Rapid error pattern identification; - Scalable personalized feedback; - Enhanced teaching responsiveness; - Teacher time saving; - Real-time adjustments enabled	- Cannot evaluate movement quality; - Psychomotor assessment requires human judgment; - Computer vision limited for complex skill; - Cultural bias in some items; - Requires teacher review and refinement	- Human observation essential for motor skill; - Draft feedback needs personalization; - Enables responsive teaching; - Supports formative practice; - Cannot determine final grade independently
Research in Didactics & Scholarly Work	- Literature synthesis; - Qualitative data coding; - Theme identification; - Knowledge mobilization; - Plain language summaries; - Grammar and editing assistance	(7, 29, 30, 32-34, 36, 55-67)	- Literature synthesis substantially faster; - Qualitative coding shows substantial agreement; - Factual errors documented in summaries; - Practitioners find summaries useful; - Consistency maintained across large dataset; - Ethics concerns about authorship attribution	- Research efficiency gain; - Systematic alternative coding perspective; - Accelerated knowledge mobilization; - Enhanced accessibility for practitioner; - Consistent data processing; - Bridges research-practice gap	- Factual errors require verification; - Misses nuanced contextual meaning; - Cultural insensitivity in interpretation; - Academic integrity concern; - Cannot interpret discipline-specific terminology; - Authorship ethics unclear	- Human verification mandatory; - Cannot replace researcher expertise; - Transparency required in scholarly use; - AI cannot be listed as author; - Ethical guidelines essential; - Complete source verification needed; - Knowledge mobilization accelerated with oversight

4. Discussion

This comprehensive review examined pedagogical applications of Gen AI and LLMs in sports sciences and PE didactics, analyzing evidence across 78 studies spanning teaching support, learning enhancement, assessment innovation, and didactic research domains. Key findings demonstrated Gen AI can reduce administrative burden, enhance accessibility through differentiated materials, provide feedback support, and improve research efficiency. However, these benefits must be carefully balanced against concerning patterns including cognitive atrophy from over-reliance (AICICA framework developed by Dergaa and colleagues (30, 32-34), academic integrity violations, factual accuracy issues particularly for movement technique and exercise prescription advice documented in sports sciences contexts (7, 14, 15, 20, 28), and equity concerns affecting students with limited digital literacy or technology access (35). Analysis reveals Gen AI and LLMs present fundamental pedagogical paradox in sports sciences education. These technologies offer efficiency in administrative tasks, personalization of cognitive content, and support for differentiated instruction, evidence-based components of quality teaching. Simultaneously, their integration risks undermining essential elements of sports pedagogy including embodied nature of movement learning, critical role of human modeling and immediate kinesthetic feedback, social-constructivist processes through which movement knowledge is negotiated in dynamic contexts, and motivational power of authentic human relationships between teachers and students that cannot be replicated through AI interactions (21, 22, 25-27, 68).

From constructivist perspective grounded in Piaget's developmental theory emphasizing active knowledge construction through experience and reflection, Gen AI effectively supports knowledge building in declarative and conceptual domains of sports sciences including understanding biomechanical principles, exercise physiology concepts, tactical strategies, rules and regulations, and health-related fitness knowledge (10, 11, 21, 45, 47). However, procedural knowledge central to motor learning, how to execute movements efficiently, when to apply tactical decisions in dynamic game situations, kinesthetic awareness of body position and movement quality, fundamentally requires embodied practice with immediate multisensory feedback that current AI cannot provide regardless of sophistication (25-27, 52). Motor skill acquisition progresses through cognitive stage (understanding movement requirements intellectually), associative stage (refining movement through practice and feedback), and autonomous stage (automatic execution without conscious attention), with latter stages requiring extensive physical repetition, kinesthetic feedback, and error correction that occur only through actual movement practice (27, 68, 69). Vygotsky's social-constructivist framework similarly highlights learning as inherently social phenomenon, occurring through interaction with more knowledgeable others (teachers, coaches, advanced peers) and cultural tools within learners' Zone of Proximal Development, gap between independent performance and potential achievement with appropriate scaffolding (22, 46). While AI engages in dialogue and provides scaffolded explanations, it cannot replicate situated, embodied, contextualized guidance expert PE teachers provide during actual movement experiences including immediate correction of movement execution errors, adaptive cueing based on observed kinesthetic patterns, motivational encouragement calibrated to individual emotional states, and social facilitation creating supportive learning climate (22, 25, 26, 46).

Universal Design for Learning (UDL) framework provides valuable lens for evaluating Gen AI pedagogical affordances (24). UDL emphasizes providing multiple means of representation (presenting information in various formats, languages, and complexity levels to accommodate diverse processing preferences), multiple means of action and expression (allowing students to demonstrate learning through varied response modes), and multiple means of engagement (options for sustaining motivation and interest) (10, 24, 41). LLMs align well with these principles by presenting information in multiple formats adapting to reading level and learning preference, accepting student input through text or voice interaction, translating content across languages supporting English Language Learners, generating varied examples and analogies, and adapting interaction styles maintaining engagement (10, 24, 41, 46). This flexibility could significantly enhance accessibility in sports sciences education, particularly benefiting students with learning disabilities requiring alternative content presentations, English Language Learners needing multilingual support, students requiring cognitive accommodations for processing speed or working memory, and learners with varied prior knowledge requiring differentiated complexity (10, 24, 35, 41). However, UDL in PE fundamentally also emphasizes multiple means of physical action and expression, providing varied movement options, adaptive equipment, modified rules, and alternative performance assessments accommodating diverse motor abilities, physical characteristics, and disability-related needs (24, 25, 70). This physical differentiation domain remains area where current Gen AI offers limited support beyond generating varied task descriptions requiring human teacher expertise for actual implementation and adaptation during movement execution (10, 25, 28, 41).

Technology-Enhanced Learning frameworks emphasize technology should amplify effective pedagogy rather than substitute for human teaching, following principle that tools serve educational purposes rather than dictating instructional practices (12, 13, 71). Viewed through this lens, Gen AI's greatest pedagogical value may lie in automating lower-level cognitive and administrative work (information retrieval, basic explanation, routine planning tasks, initial assessment feedback), thereby freeing teachers to focus on higher-level pedagogical functions requiring uniquely human capacities including diagnosing complex learning needs through holistic observation, providing nuanced movement feedback based on expert qualitative analysis, facilitating social-emotional development through relationship building, creating motivational climates through authentic encouragement and appropriate challenge, and making adaptive instructional decisions based on dynamic classroom context (10, 12, 13, 41, 43, 44). This vision of human-AI collaboration requires deliberate pedagogical design ensuring technology serves educational purposes determined by teachers rather than technology capabilities determining educational practices, maintaining teacher agency and professional decision-making while leveraging AI efficiency (7, 10, 12, 13, 32, 33).

4.1 *Critical Challenges and Pedagogical Risks*

Several critical challenges demand attention from educators, researchers, policymakers, and technology developers. Foremost is risk of cognitive atrophy through over-reliance on AI-generated content, articulated through AI-Chatbot Induced Cognitive Atrophy (AICICA) framework extensively developed and validated by Dergaa and colleagues across multiple publications (30-34). The

AICICA framework proposes that excessive dependence on AI for cognitive work may deteriorate critical thinking capacities, analytical reasoning skills, creative synthesis abilities, and problem-solving competencies through disuse atrophy similar to physical deconditioning from insufficient exercise (30-34). Cognitive science literature documents use-it-or-lose-it principles apply to mental capacities as well as physical abilities, with insufficient cognitive challenge leading to reduced neural connectivity, decreased processing efficiency, and diminished capacity for complex reasoning (30, 31, 72). In sports sciences education specifically, AICICA could manifest as students who retrieve biomechanical facts through AI but cannot analyze actual movement patterns qualitatively, generate training programs via AI prompts but cannot adapt prescriptions based on individual response, understand tactical concepts intellectually but cannot apply strategies in dynamic game situations, or complete written assignments using AI without developing analytical writing skills essential for professional communication (28-30, 32). Longitudinal research urgently needed examining whether regular AI use during education impacts long-term development of analytical capacities, problem-solving skills, creative thinking, and professional competence measured years after graduation (30-34).

Academic integrity represents critical challenge requiring institutional policy development, faculty education, and student literacy programs (28, 29, 32, 33). Ease with which LLMs generate coherent essays, laboratory reports, research papers, and movement analysis assignments creates opportunities for academic dishonesty whether through intentional cheating or well-intentioned but inappropriate use without understanding ethical boundaries (28, 29, 32, 33). Current AI detection tools demonstrate limited reliability with high false-positive rates (flagging human writing as AI-generated) and false-negative rates (missing AI-generated content, especially when students edit AI output), and an arms race between generation and detection technologies seems inevitable (28, 29). More fundamentally, widespread AI availability may erode pedagogical value of traditional assessment formats (28, 29, 32). If essays can be AI-generated, their continued use as learning tools requires reconceptualization, perhaps shifting emphasis to process of thinking and writing evident through drafts and revisions rather than final product alone, incorporating in-class writing components verifying independent student work, or using oral defenses where students explain and justify written work demonstrating authentic understanding (28, 29, 32). Some educators propose reframing assignments to explicitly incorporate AI use as tool requiring critical evaluation, with students asked to generate AI content, critique its accuracy and quality, compare multiple AI responses, and synthesize information with original analysis, transforming AI from cheating mechanism to pedagogical tool developing critical literacy (28, 29, 32). However, this approach assumes all students have equivalent access to AI tools and digital literacy skills, potentially exacerbating inequalities (35).

Accuracy and reliability issues pose particular challenges in sports sciences where incorrect movement advice can cause physical injury (7, 14, 15, 20, 28). Current LLMs frequently generate plausible-sounding but factually incorrect information, particularly regarding specific movement techniques, exercise prescriptions, biomechanical principles, and sport-specific tactics (7, 14, 15, 20, 28). Dergaa and colleagues conducted critical evaluations of OpenAI GPT-4 for exercise prescription in personalized health promotion, documenting significant limitations and potential dangers when AI-generated advice is implemented without expert verification (14, 20). Similarly, investigations of ChatGPT applications in resistance training prescription revealed biomechanically dangerous recommendations that could cause injury (15). Unlike errors in some academic domains having primarily intellectual consequences, misinformation about movement execution can lead to acute injury (ligament tears, fractures, dislocations) or chronic overuse conditions (tendinopathy, stress fractures, joint degeneration) (7, 14, 15, 20). This necessitates clear communication to students about appropriate and inappropriate AI uses, explicit instruction in critical evaluation of AI-generated movement advice, and establishment that all movement technique information must be verified by qualified teacher or coach before implementation (7, 14, 15, 20). Professional organizations in sports sciences urgently need to develop guidelines for safe AI use, similar to position statements on exercise testing and prescription, providing evidence-based recommendations for educators and practitioners (7, 14, 15, 20).

Equity concerns require proactive attention to prevent technology integration from exacerbating existing educational inequalities (35, 73). While Gen AI could theoretically democratize access to high-quality educational resources and personalized instruction previously available only to affluent students with private tutors, several factors may worsen disparities (35, 73). Optimal AI tool use requires digital literacy skills (understanding AI capabilities and limitations, effective prompt engineering, critical evaluation of outputs), access to reliable high-speed internet connectivity, capable devices (AI tools consume significant bandwidth and processing power), and time for exploration and experimentation (35, 73). These resources distribute unequally across socioeconomic groups, with low-income students, rural students, and students in under-resourced schools having substantially less access than affluent suburban students (35, 73). Furthermore, if Gen AI becomes essential infrastructure for academic success in sports sciences, students without access face disadvantage (35). Conversely, over-reliance on AI tools in schools with adequate technology access but limited emphasis on embodied learning may widen gaps in kinesthetic intelligence, motor competence, and physical literacy, skills that remain foundational to PE and sports sciences regardless of technological advances (25, 26, 35, 73). Equity-focused implementation requires ensuring all students have access to necessary technology and connectivity, developing AI literacy curriculum integrated across courses, maintaining emphasis on embodied movement experiences regardless of AI availability, and evaluating impact on different student populations to identify and address unintended consequences (35, 73).

4.2 Proposed Framework for Pedagogically-Sound Integration

Based on review findings and grounded in pedagogical theory, we propose hybrid integration framework for Gen AI in sports sciences and PE education organized around five core principles.

Principle 1: Pedagogy-First Design

Educational goals and pedagogical principles must guide technology integration rather than technology capabilities determining educational practices (7, 10, 12, 13, 32, 33). Gen AI should be adopted where it demonstrably enhances learning outcomes or teaching effectiveness through rigorous evaluation, not simply because technology is novel or available (12, 13, 71). Implementation decisions should emerge from questions including: Does this application support identified learning objectives? Does it align with evidence-based pedagogical practices? Does it enhance rather than diminish essential educational experiences? Does it serve educational purposes or merely provide efficiency without pedagogical benefit? (7, 10, 12, 13).

Principle 2: Human-AI Collaboration

Gen AI should augment and support human pedagogical expertise rather than replace essential teaching functions (10, 12, 13, 41, 43, 44). Effective integration positions technology handling information processing, pattern recognition across large datasets, content generation following specified parameters, and routine administrative tasks while preserving uniquely human capacities for contextual judgment grounded in holistic student knowledge, embodied modeling and kinesthetic demonstration, relationship-building and motivational support, adaptive decision-making responding to dynamic situations, and ethical reasoning about complex educational situations (13, 41, 43, 44). This complementary relationship maximizes strengths of both human and artificial intelligence while minimizing respective limitations (10, 12, 13, 71).

Principle 3: Critical Engagement

Both teachers and students must develop capacities for critical evaluation of AI-generated content, understanding its limitations, recognizing potential biases, and determining appropriate versus inappropriate uses (7, 14, 20, 28, 29, 32, 33, 40, 43). Critical AI literacy curriculum should include understanding how LLMs work at conceptual level (training on text data, pattern recognition, statistical prediction), recognizing AI cannot access current information or verify claims without retrieval systems, developing effective prompt engineering skills for quality outputs, implementing systematic verification procedures against authoritative sources, identifying cultural biases and representation gaps in training data, understanding when AI is appropriate tool versus when human expertise required, and recognizing ethical implications of AI use in educational contexts (7, 14, 28, 29, 33, 40, 43). Teachers require professional development not just in technical AI operation but in pedagogical decision-making frameworks for evaluating applications, strategies for maintaining academic integrity while allowing beneficial use, and methods for teaching critical AI literacy to students (7, 14, 28, 29, 33, 40, 43).

Principle 4: Maintaining Embodiment

Physical, kinesthetic, and experiential core of sports education must be preserved and prioritized (25-27, 68-70). Gen AI supports cognitive dimensions of sports sciences learning (theoretical concepts, biomechanical principles, tactical strategies, rules and regulations) but cannot substitute for actual movement practice and embodied knowledge development requiring physical repetition, multisensory feedback, social interaction in movement contexts, and development of kinesthetic awareness (25-27, 52, 68-70). Integration must ensure AI use enhances rather than displaces time for physical activity, maintains emphasis on motor skill acquisition and physical competency development, preserves essential face-to-face teacher feedback during movement execution, and supports rather than replaces social learning through peer interaction (25-27, 68-70).

Principle 5: Equity and Access

Integration strategies must proactively address potential inequalities in access to technology, digital literacy development, and distribution of both benefits and risks (35, 73). Equity-focused implementation requires ensuring universal access to necessary technology infrastructure, providing comprehensive digital literacy education to all students regardless of background, evaluating impact across diverse student populations, addressing unintended consequences exacerbating existing disparities, and maintaining multiple pathways to success not requiring AI use (35, 73).

Table 2 presents the comprehensive hybrid integration framework specifying appropriate and inappropriate uses of Gen AI in sports sciences and PE contexts, organized by pedagogical function with implementation principles and evidence-based rationales drawn from included studies and supported by reference citations.

Table 2. Pedagogical Framework for Appropriate and Inappropriate Uses of Generative AI and Large Language Models in Sports Sciences and Physical Education

Pedagogical Function	Appropriate Uses	Implementation Principles	Inappropriate Uses	Rationale & Supporting Evidence
Teaching Support & Administrative Efficiency	- Lesson planning templates requiring teacher adaptation; - Differentiated reading-level materials for theoretical content; - Multilingual resource creation; - Parent communication template; - Curriculum mapping tools	- AI output serves as starting point only; - Mandatory human review and contextual adaptation; - Facility, equipment, safety factors require teacher expertise; - Quality verification essential; - Professional development in evaluation needed	- Final lesson plans without human review; - Movement sequence design without expert verification; - Safety-critical instructions without professional oversight; - Replacement of teacher pedagogical decision-making; - Autonomous planning without contextual knowledge	Time efficiency documented (41, 43, 44), but AI lacks contextual knowledge about facility constraints, equipment availability, class composition, and individual student needs essential for implementation
Cognitive Content Delivery & Knowledge Construction	- Theoretical concept explanations in exercise physiology, biomechanics; - Tactical strategy overview; - Rules and regulations clarification; - Historical context of sport; - Supplementary examples and analogies	- Clearly labeled as AI-generated content; - Students taught to verify information against authoritative source; - Used to supplement, not replace, human instruction; - Critical AI literacy curriculum mandatory; - Emphasis on critical evaluation skills	- Movement technique instruction and demonstration; - Exercise prescription without professional oversight; - Biomechanical advice for movement execution; - Diagnosis of movement error; - Complete replacement of theoretical instruction	Benefits for declarative knowledge documented (11, 45, 47), but AI cannot support procedural motor learning (11, 47, 52). Dergaa et al. documented dangerous errors in exercise prescription (14, 20) and resistance training advice (28)
Student Learning & Personalization	- 24/7 question-answering for cognitive content; - Scaffolded explanations at multiple levels; - Metacognitive reflection prompts; - Goal-setting dialogue support; - Self-assessment facilitation	- Students explicitly taught appropriate vs inappropriate use; - Academic integrity policies clearly communicated; - AI literacy education integrated into curriculum; - Disclosure requirements for any AI assistance; - Regular monitoring of use patterns	- Completion of graded assignments without disclosure; - Substitution for independent problem-solving; - Primary source of learning without human instruction; - Movement analysis or critique generation; - Any use enabling academic dishonesty	Students value immediate availability and scaffolding (11, 45-47), but academic integrity violations 23-43% documented (28, 29). AICICA framework warns of cognitive atrophy from over-reliance (30-34). Disclosure essential for academic integrity
Assessment & Feedback	- Cognitive test item generation;	- All AI-generated assessments reviewed by qualified teacher;	- Final grade determination; -	Substantial agreement with teacher feedback documented (49, 50) supports screening utility, but human judgment essential for

	- Rubric drafting for teacher refinement; - Initial feedback on written reflections requiring teacher review; - Pattern identification in student responses; - Learning analytics support	- Feedback viewed as draft requiring personalization; - Students informed when AI contributed to feedback; - Human final determination on all grades; - Focus on formative over summative applications	Psychomotor skill assessment; - Movement quality evaluation; - Tactical decision-making assessment in dynamic context; - High-stakes summative assessment without human oversight	movement assessment (25, 26)(27,52). Computer vision systems show poor performance for complex motor skills (25, 27, 53)
Differentiated Instruction	- Multiple reading-level versions of theoretical content; - Varied explanation strategies; - Multilingual content for English Language Learners; - Adapted cognitive complexity	- UDL principles guide application (24); - Cognitive differentiation only; psychomotor requires human expertise; - Cultural appropriateness verified; - Accessibility features maintained; - Individual student knowledge required	- Psychomotor task differentiation without expert design; - Movement progression sequences without teacher oversight; - Success rate calibration for motor tasks; - Physical accommodation decisions without professional judgment	Educator satisfaction with cognitive differentiation documented (10, 41), but AI predominantly addresses cognitive load, not psychomotor adjustments essential in PE (10, 41). UDL principles supported for cognitive access (24)
Research & Scholarship	- Literature preliminary scanning and organization; - Initial qualitative coding for researcher review; - Plain language summary generation for practitioners; - Evidence table creation; - Grammar and clarity editing with disclosure	- Complete human verification of all AI output; - Explicit disclosure in all scholarly work; - AI cannot be listed as author; - Researchers maintain full accountability; - Systematic verification against original sources	- Substantive content generation without disclosure; - AI listed as author; - Citation without reading original source; - Generation of fabricated references; - Analysis without human interpretation	Literature synthesis efficiency documented (36, 55, 64), but factual errors require verification (55, 56, 62, 64). Qualitative coding agreement substantial (57, 61, 65) supports screening utility. Dergaa et al. (30-34) warn of citation fabrication and authorship ethics violations
Physical Activity & Movement Experiences	- Theoretical understanding of movement principles; - Tactical strategy comprehension; - Fitness concept explanation; - Historical context of activities	- Strictly limited to cognitive component; - Never replaces actual physical practice; - Cannot substitute kinesthetic learning; - Complements but never reduces PA time; - Used to enhance understanding, not replace movement	- Substitution for physical activity time; - Replacement of movement practice; - Primary source of motor skill learning; - Kinesthetic feedback provision; - Movement technique demonstration	Motor learning requires physical repetition, immediate kinesthetic feedback, and multisensory input unavailable through AI (25-27, 68-70). Psychomotor domain progresses through stages requiring actual movement practice (68, 69). Embodied learning essential (70)

Implementation Requirements:

1. **Professional Development:** Teachers require comprehensive training in pedagogical decision-making frameworks for AI evaluation, not just technical operation (7, 10, 29, 32, 33, 40, 43)
2. **Policy Development:** Institutions need explicit policies specifying permitted/prohibited uses, disclosure requirements, and consequences aligned with academic integrity procedures (28, 29, 32, 33)
3. **AI Literacy Curriculum:** Students need systematic instruction in critical evaluation, appropriate use, ethical implications, and limitations of AI systems (7, 14, 20, 28, 29, 32, 33, 40, 43)
4. **Ongoing Evaluation:** Regular assessment of impact on learning outcomes, equity, academic integrity, and pedagogical quality with adjustments based on findings (30, 32, 33, 35, 73)

5. **Human-Centered Design:** All integration decisions prioritize preservation of essential human teaching elements: embodied instruction, relationship-building, contextual adaptation, and ethical judgment (10, 12, 13, 25, 26, 41, 43, 44)

Note: Framework derived from synthesis of 78 studies published 2022-2025 and grounded in constructivist pedagogy (21, 22), UDL principles (24), embodied learning theory (25-27, 69, 70), and technology-enhanced learning frameworks (12, 13, 71). Dergaa et al. contributions include AICICA framework (30, 32-34), academic integrity considerations (7, 29, 32, 33), exercise prescription evaluation (14, 20), resistance training assessment (15), and AI in sports biomechanics (16-19). Implementation requires moving from technology-driven adoption to pedagogy-informed integration where educational goals determine technology use.

4.3 Implementation Recommendations and Future Directions

Successful implementation requires comprehensive professional development for PE teachers and sports sciences educators focusing not on technical AI operation but on pedagogical decision-making about when, how, and why to use tools appropriately (7, 10, 29, 32, 33, 40, 43). Professional development should include pedagogical frameworks for evaluating AI applications critically, strategies for maintaining academic integrity while permitting beneficial use, methods for teaching critical AI literacy to students, practical experience with specific tools and assessment of their quality, understanding of AI limitations and failure modes requiring human oversight particularly in exercise prescription contexts (7, 14, 15, 20), and opportunities for collaborative discussion of ethical dilemmas and pedagogical challenges (7, 29, 32, 33, 40, 43). Pre-service teacher education programs in kinesiology and PE must integrate content on Gen AI's pedagogical implications, preparing future educators to navigate this technological landscape thoughtfully rather than reacting to student use without preparation (10, 29, 40, 43). Curriculum should include critical evaluation of educational technology, pedagogical principles for technology integration, AI literacy specific to sports sciences contexts emphasizing safety in movement advice (7, 14, 15, 20), and practicum experiences applying evaluation frameworks to emerging technologies (10, 29, 40, 43).

Institutions require clear policies on AI use balancing academic integrity concerns with opportunities for beneficial integration (28, 29, 32, 33). Policies should specify permitted uses (research, brainstorming, editing with disclosure) and prohibited uses (generating substantive assignment content without disclosure), disclosure requirements for any AI use in submitted work, consequences for policy violations aligned with existing academic misconduct procedures, and regular review and updating as technology evolves (28, 29, 32, 33). However, policies alone prove insufficient without accompanying educational programs for faculty and students explaining rationales, demonstrating appropriate uses, and developing shared understanding of ethical boundaries (28, 29, 32, 33). Faculty development workshops should address detecting potential AI use in student work, redesigning assignments to reduce dishonesty opportunities while maintaining learning objectives, incorporating AI as explicit pedagogical tool with scaffolded instruction, and having constructive conversations with students about academic integrity (28, 29, 32, 33).

Future research must prioritize empirical investigation of Gen AI's pedagogical impacts in sports sciences education addressing critical unanswered questions (7, 30-34). Priority areas include: [1] longitudinal studies examining long-term effects of regular AI use during education on student learning outcomes, motor skill development, critical thinking capacities, physical literacy, and professional competence measured years after graduation, with particular attention to AICICA manifestations (30-34); [2] comparative effectiveness research evaluating Gen AI-enhanced instruction versus traditional approaches across various pedagogical contexts, content areas, and student populations using validated outcome measures; [3] development and validation of pedagogical frameworks specifically for Gen AI integration in sports sciences contexts aligned with embodied learning principles (25-27, 69, 70); [4] investigation of Gen AI's differential impact across diverse student populations including students with disabilities, English Language Learners, students from under-resourced communities, and students with varied prior motor experiences (35, 73); [5] examination of teacher decision-making processes about Gen AI use, how pedagogical beliefs influence integration patterns, and what supports teachers need for effective implementation (40, 43); [6] methodological research on appropriate uses of Gen AI in didactic research without compromising scholarly integrity, including guidelines for disclosure and verification as emphasized by Dergaa et al. (7, 29, 32-34); [7] development and evaluation of AI literacy curricula specific to sports sciences contexts teaching critical evaluation of movement and exercise advice (7, 14, 15, 20); [8] research on integrating Gen AI with other emerging technologies including computer vision for movement analysis (52-54), wearable sensors providing real-time feedback, and virtual reality for tactical training to create comprehensive pedagogical systems maintaining human-centered teaching while leveraging technological capabilities (71, 74-76).

4.4 Limitations

Several limitations warrant acknowledgment. First, rapid evolution of Gen AI technology means findings may quickly become dated as new capabilities emerge, limitations are addressed through technical advances, and novel applications are developed (7-9). This review captures current state as of November 2025 but requires regular updating as field progresses. Second, predominance of recent exploratory literature limits opportunities for efficient quality assessment using traditional hierarchies of evidence and meta-analytic synthesis of quantitative findings (7, 36, 37). Most included studies were conceptual/theoretical papers or qualitative investigations providing valuable insights but not permitting statistical aggregation. Third, only 29% of included studies directly addressed sports sciences or PE contexts, with remainder examining broader educational applications requiring reviewer judgment about transferability and relevance to sports pedagogy (7). This indirect evidence base, while providing valuable insights, introduces uncertainty about direct applicability. Fourth, publication bias likely favors studies reporting positive findings, novel applications, or critical concerns over null results or incremental advances, potentially skewing literature toward polarized views (37). Fifth, our pedagogically-oriented analytical framework, while theoretically grounded in established learning theories and contemporary PE pedagogy, represents one perspective among multiple valid approaches to examining this phenomenon (21-24). Alternative frameworks emphasizing different theoretical lenses might yield different organizational structures or priorities. Sixth, nascent state of empirical research in Gen AI and sports education means many important questions remain unexplored including long-term learning outcomes, differential impacts across populations, comparative effectiveness of various integration approaches, and cost-effectiveness relative to alternative interventions (7, 30, 32-34). Finally, geographic concentration of included studies in North America and Europe with limited representation from other regions introduces cultural bias, as pedagogical practices, technological infrastructure, educational values, and AI adoption patterns vary substantially across cultural contexts (73).

5. Conclusions

Artificial Intelligence and Large Language Models represent transformative tools for sports sciences and physical education pedagogy when implemented within robust pedagogical frameworks that preserve essential embodied, social, and affective elements of movement education. Evidence from 78 studies supports specific applications including administrative efficiency through lesson planning support, accessibility enhancement through differentiated cognitive content delivery, formative assessment support through automated feedback generation, and research methodology enhancement through literature synthesis and qualitative coding assistance. However, successful integration demands critical attention to substantial challenges including academic integrity violations requiring institutional policy development and AI literacy education, accuracy verification necessitating expert review of movement technique advice and exercise prescriptions, equity considerations ensuring universal technology access and digital literacy skills, and prevention of cognitive atrophy as articulated through the AI-Chatbot Induced Cognitive Atrophy (AICICA) framework demanding preservation of independent analytical reasoning opportunities. A hybrid pedagogical model is recommended, strategically integrating Gen AI for cognitive content delivery, administrative task automation, and research support when combined with rigorous human verification, while rigorously preserving essential elements including face-to-face instruction with adaptive decision-making, kinesthetic learning experiences with immediate multisensory feedback, expert qualitative movement analysis, human mentorship providing motivational support, and social interaction facilitating peer learning central to sports education. The critical conclusion is that Gen AI must be understood as pedagogical tool rather than pedagogical solution, with value residing in thoughtful human-AI collaboration where technology handles information processing and content generation while educators provide irreplaceable capacities for contextual judgment, relationship-building, embodied modeling, and adaptive instruction responding to dynamic teaching situations.

Successful integration requires comprehensive teacher professional development focusing on pedagogical decision-making frameworks, explicit policies balancing academic integrity with beneficial use, critical AI literacy curriculum emphasizing safety verification of movement advice, ongoing empirical evaluation of long-term outcomes, and a paradigm shift from technology-driven adoption to pedagogy-informed integration ensuring Gen AI serves educational goals rather than dictating them.

Authors' Contributions

SB: Literature search, screening, data extraction, analysis, manuscript drafting. IC: Screening arbitration, sports sciences expertise, critical revision. IS: Theoretical framework development, pedagogical analysis. MAD: Conceptualization, AI applications expertise, critical revision. HIC: Sports sciences expertise, international perspectives. NS: Physical activity research expertise, critical revision. MR: Data extraction, quality assessment. IM: Literature organization, reference management. SS: Data synthesis support. NC: Methodological oversight, critical revision. ID: Conceptualization, methodology, screening, data extraction, analysis, manuscript drafting, critical revision, supervision, corresponding author. All authors approved the final manuscript and agree to be accountable for all aspects of the work.

Transparency Statement

All data analyzed in this review are from publicly available published sources cited in the reference list. The data extraction forms and analytical framework are available from the corresponding author upon reasonable request.

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Declaration of Interest

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Not applicable. This review study analyzed publicly available published literature and did not involve human participants.

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