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AI-ENHANCED SPORTS AND CHILD DEVELOPMENT: OPPORTUNITIES, RISKS AND THE FUTURE OF PHYSICAL EDUCATION

Dr. Neelam C Dey
Global Center for Social Dynamic Research
globalcsdr@gmail.com

ABSTRACT

Artificial intelligence (AI) is increasingly transforming the sporting environment through performance analytics, wearable technologies, computer vision, movement tracking, predictive modelling, injury-risk assessment and personalized training. While these technologies have predominantly been developed and evaluated in elite and professional sport, their gradual movement into schools, youth academies and community sports creates important questions about their implications for children and adolescents. Sport is not merely a mechanism for improving physical fitness. During childhood and adolescence, participation in physical activity and sport can contribute to cognitive development, emotional regulation, social interaction, self-confidence, discipline, cooperation, resilience and identity formation. Consequently, the introduction of AI into children's sporting environments must be assessed not only according to its capacity to improve measurable athletic performance but also according to its impact on children's broader developmental wellbeing.

This paper examines the emerging intersection of artificial intelligence, children's sport and physical education through a narrative review of research and international policy literature. Evidence indicates that AI may support individualized training, movement assessment, injury-risk identification, accessibility, feedback and data-informed decision-making. Machine-learning research in sports injury prediction has already demonstrated considerable potential, although evidence remains heterogeneous and methodological limitations are substantial. At the same time, the use of AI and biometric technologies among children raises significant concerns concerning privacy, informed consent, data ownership, surveillance, algorithmic bias, psychological pressure, excessive performance comparison and the possibility that technology could displace meaningful relationships between children, coaches, teachers and parents.

The paper identifies a significant research gap: the existing AI-in-sport literature is disproportionately focused on adult, elite or professional athletes, whereas evidence concerning children in school and community settings remains comparatively limited. The paper therefore proposes a human-centred AI-enhanced physical education framework in which technology is used as a supportive instrument rather than as a replacement for professional judgement, play, creativity or interpersonal relationships. Future physical education should integrate physical literacy, digital literacy and AI literacy while establishing strong safeguards for children's data and wellbeing. The paper concludes that the success of AI in children's sport should not be measured solely by faster performance, better prediction or greater athletic output, but by whether technology enables children to become healthier, more confident, physically literate, socially connected and capable of making informed decisions about technology.

Keywords: Artificial Intelligence; Children; Sports; Child Development; Physical Education; Physical Literacy; Digital Literacy; AI Literacy; Sports Analytics; Wellbeing; Wearable Technology; Injury Prevention; Ethics

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1. INTRODUCTION

The rapid development of artificial intelligence is changing the way information is collected, interpreted and used across education, healthcare, business and sport. In sports, AI-based systems can process large quantities of physiological, biomechanical and performance information and convert these data into predictions or recommendations. Computer vision can analyse movement patterns, wearable devices can continuously monitor physiological variables, and machine-learning models can identify patterns associated with performance or injury risk. These developments have created a new technological environment in which sporting performance can increasingly be measured, predicted and personalized.

The significance of this transformation becomes considerably greater when AI enters childhood and school-based sport. Children are not simply smaller versions of adult athletes. Their bodies, cognitive abilities, emotional regulation, social relationships and decision-making capacities are undergoing continuous development. A technology that may be appropriate for an elite adult athlete cannot automatically be assumed to be appropriate for a child. The objectives of children's sport should therefore extend beyond optimization of performance. They should include enjoyment, physical literacy, healthy development, participation, inclusion, confidence and the development of lifelong physical-activity habits.

The importance of physical activity during childhood is well established. The World Health Organization recommends that children and adolescents aged 5–17 years undertake an average of at least 60 minutes of moderate-to-vigorous physical activity per day across the week. Physical activity is associated with benefits to physical fitness, cardiometabolic health, bone health, cognitive outcomes and mental health.

However, global levels of physical activity remain a major concern. A WHO-led analysis involving approximately 1.6 million school-going adolescents aged 11–17 years across 146 countries found that more than 80% did not meet the recommended level of daily physical activity. The proportion was approximately 85% among girls and 78% among boys. This creates an important paradox. At precisely the time when societies are attempting to increase children's physical activity, technological development is making it possible to measure physical behaviour more intensively than ever before.

The challenge, therefore, is not whether AI should be introduced into children's sport in absolute terms. The more meaningful question is how AI can be integrated without transforming physical education into a technologically controlled performance environment. AI should support teachers and coaches in understanding children's needs while preserving the human, playful and developmental characteristics of sport.

2. BACKGROUND AND RATIONALE

Physical education traditionally operates through direct observation, instruction, practice, feedback and social interaction. Teachers and coaches observe movement, identify difficulties, provide encouragement and adapt activities according to children's individual needs. Their role extends beyond technical instruction because they also influence children's motivation, confidence, social development

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Vol. 2| Issue 5 | May 2026 | pp 1-14

and attitudes toward physical activity.

AI introduces a different model. Instead of relying exclusively on human observation, technological systems can collect continuous information about movement, speed, acceleration, heart rate, workload, sleep, training volume and other variables. Computer vision may identify movement patterns from video, while machine-learning systems may compare individual performance with historical data or population-level patterns.

Such capabilities can potentially make physical education more individualized. A child struggling with balance or coordination, for example, could receive more targeted exercises. A teacher could identify changes in participation or movement quality over time. A coach could use workload information to avoid unnecessarily excessive training. Children with certain disabilities could potentially benefit from adaptive technologies that provide personalized feedback and alternative ways of participating.

Yet greater measurement does not necessarily mean better development. A child's sporting experience may become problematic if every movement is scored, ranked or compared. Continuous monitoring can transform sport from an enjoyable activity into an environment in which children feel permanently evaluated. Ethical concerns surrounding biometric technologies already include privacy, autonomy, confidentiality, surveillance, data security and coercion. These concerns become more significant when the individuals being monitored are minors.

The rationale for this paper therefore emerges from the need to examine AI in children's sport from a developmental rather than purely performance-oriented perspective.

3. PROBLEM STATEMENT

The central problem addressed by this paper is the growing gap between the rapid development of AI technologies for sport and the comparatively limited evidence concerning their appropriate use among children and adolescents.

Much of the existing sports-AI literature focuses on elite athletes, professional teams, adult populations and performance optimization. Research on machine learning and sports injury prediction, for example, demonstrates promising predictive capabilities, but the evidence base has historically been relatively small and methodologically heterogeneous. One systematic review identified only 11 eligible studies from 249 records and reported predictive performance ranging from poor models with an AUC of 0.52 to substantially stronger models with an AUC of 0.87. The authors nevertheless emphasized the need for improved methodology and better interpretation of machine-learning models.

This creates a critical problem when technologies designed or validated in adult sporting environments are transferred to children. Children differ from adults in physical growth, maturation, motor development, psychology and social circumstances. An algorithm trained on adult athletes may therefore not be sufficiently valid or appropriate for a developing child.

A second dimension of the problem concerns ethics. Children's sports data can potentially include highly sensitive information such as physiological measurements, movement patterns, images, location information, health indicators and performance histories. If such information is collected without meaningful understanding or adequate safeguards, children may have little control over information that can remain associated with them for many years.

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A third dimension concerns the educational purpose of physical education. If AI systems emphasize speed, rankings, calories, scores or performance optimization, they may unintentionally narrow the purpose of physical education. The long-term objective should be to develop physically active, confident and physically literate individuals rather than simply to produce better-performing young athletes.

The problem can therefore be summarized as follows: how can schools and sports organizations capture the educational and developmental benefits of AI while preventing excessive surveillance, performance pressure, inequality, privacy violations and the erosion of human relationships in children's sport?

4. RESEARCH GAP

The most important research gap identified in the literature is the limited integration of three fields that have generally developed separately: AI in sport, child development and physical education.

Sports-AI research has made considerable progress in performance analysis, injury prediction, biomechanics and athlete monitoring. However, many studies concern adult or elite populations. A recent review of machine-learning approaches to sports injury prediction identified 38 relevant studies from a larger search and found football to be the most frequently studied sport. The review also identified considerable variation in methods and outcomes, indicating that predictive performance does not automatically translate into reliable real-world application.

Meanwhile, research on physical literacy emphasizes the importance of physical competence, motivation, confidence, knowledge and understanding. A systematic review describes physical literacy as involving cognitive, affective and physical dimensions rather than physical competence alone. School-based physical-literacy interventions similarly demonstrate that children's physical development needs to be considered holistically rather than through a single performance metric.

The research gap therefore lies in understanding how AI can contribute to holistic child development through sport, rather than simply improving athletic performance.

A further gap exists in relation to children's participation in decisions concerning their own sports data. UNICEF's current guidance emphasizes child safety, privacy, fairness, transparency, accountability, inclusion, wellbeing and children's preparation for an AI-enabled future. Yet these principles have not been sufficiently translated into practical frameworks specifically designed for AI-enabled school sports and physical education.

There is also a geographical and socioeconomic gap. AI-enabled sport may be more accessible to well-funded private schools, elite academies and professional sports organizations than to government schools or community programs. If AI becomes an important component of high-quality physical education without equitable access, technological adoption could unintentionally widen existing inequalities.

5. REVIEW METHODOLOGY

This paper adopts a narrative systematic-review approach, combining peer-reviewed academic

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literature with authoritative policy and international guidance published primarily between 2015 and 2026. The review focuses on four intersecting areas: artificial intelligence and sports analytics, AI and sports injury prediction, physical activity and physical literacy among children, and ethical governance of AI and wearable technologies involving minors.

Relevant literature was identified through searches of academic and institutional sources using combinations of terms including “artificial intelligence,” “machine learning,” “sports analytics,” “children,” “adolescents,” “physical education,” “physical literacy,” “wearable technology,” “injury prediction,” “AI ethics,” “child privacy” and “sports data.”

The review gives particular attention to systematic reviews, peer-reviewed research, WHO guidance, UNESCO guidance and UNICEF policy guidance. Studies focused exclusively on adult elite athletes were used cautiously to identify technological possibilities and ethical concerns, but their findings were not automatically generalized to children.

The paper is conceptual rather than empirical. It does not claim to measure the effectiveness of a specific AI system among children. Instead, it synthesizes current evidence and develops a framework for responsible future implementation and research.

6. CURRENT EVIDENCE AND SELECTED DATA

The available evidence demonstrates both the urgency of increasing physical activity among young people and the potential of technology to support sporting development.

Table 1. Selected evidence relevant to AI-enhanced children's sport

Indicator	Evidence
Recommended physical activity for children aged 5–17	≥60 minutes/day of moderate-to-vigorous activity
School-going adolescents not meeting activity recommendations	>80% globally
Girls not meeting recommendations	85%
Boys not meeting recommendations	78%
Adolescents included in global WHO analysis	~1.6 million
Countries represented in analysis	146
Studies included in an early systematic review of ML sport-injury prediction	11 of 249 records
Reported injury-prediction performance in that review	AUC 0.52–0.87

Sources: WHO physical-activity guidelines and global adolescent physical-activity analysis; Claudino et al./related systematic-review evidence on machine learning and sports injury prediction.

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Global E-Journal of Social Scientific Research
Vol. 2| Issue 5 | May 2026 | pp 1-14

Figure 1. Physical inactivity among adolescents

WHO recommendation: ≥60 minutes/day of moderate-to-vigorous

physical activity on average across the week.

The data illustrate why technology should not become an end in itself. The fundamental public-health challenge remains getting children and adolescents to participate in enjoyable physical activity. AI should therefore be evaluated according to whether it helps solve this problem rather than simply increasing the quantity of data collected about young people.

7. AI APPLICATIONS IN CHILDREN'S SPORTS

7.1 PERSONALIZED TRAINING AND FEEDBACK

One of the strongest opportunities offered by AI is personalization. Children within the same age group can differ substantially in physical competence, coordination, confidence, motivation and developmental stage. A uniform training program may therefore be inappropriate for some children.

AI-assisted systems can potentially analyse movement and provide individualized feedback. For example, computer vision could identify aspects of running, jumping, throwing or balance that require improvement. A system could then recommend age-appropriate exercises that allow children to progress gradually.

However, personalization should not become premature specialization. Childhood sport should provide opportunities for experimentation and exposure to different movements rather than optimizing children for one narrow performance outcome.

7.2 Injury Prevention

Injury prediction is one of the most frequently discussed applications of machine learning in sports. AI can process multiple variables simultaneously, including training load, previous injuries, movement patterns and physiological information. Research has demonstrated that machine-learning methods can identify potentially important injury-risk factors, although evidence quality and generalizability remain limitations.

For children, the potential benefit is particularly important because preventing avoidable injury can support continued participation and reduce fear associated with sport. Nevertheless, an AI prediction should never be interpreted as a medical diagnosis. A child should not be excluded from participation solely because an algorithm assigns a high-risk score. Human assessment by appropriately qualified

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Vol. 2| Issue 5 | May 2026 | pp 1-14

professionals must remain central.

7.3 Movement and Skill Assessment

AI-powered computer vision could assist teachers in assessing movement skills at scale. Instead of relying exclusively on subjective observation, systems could provide supplementary information about posture, coordination, balance, jumping technique or running mechanics.

This may be especially useful in large classes where teachers have limited time to observe every child individually. However, AI-generated measurements should be interpreted as supporting evidence rather than objective truth. Movement quality is context-dependent, and children may perform differently because of confidence, fatigue, motivation, disability or unfamiliarity with an activity.

7.4 Inclusion and Accessibility

AI may also contribute to inclusive physical education. Adaptive interfaces, computer vision and personalized feedback could potentially allow children with disabilities to participate in modified sporting activities. UNICEF identifies improved accessibility and support for children with disabilities among the potential benefits of appropriately designed AI systems.

This application is particularly important because inclusion should be treated as a core objective rather than an optional feature. An AI system that improves performance for already advantaged athletes but excludes children with disabilities would not represent successful educational innovation.

7.5 Motivation and Engagement

Gamification and intelligent feedback could potentially make physical education more engaging. AI could design age-appropriate challenges, recommend activities according to interests and provide encouraging feedback.

However, excessive gamification may create a dependency on digital rewards. Children should learn to enjoy movement itself rather than believing that physical activity is valuable only when accompanied by points, badges, rankings or digital rewards.

8. AI AND CHILD DEVELOPMENT

The developmental significance of sport requires a broader understanding of what constitutes success.

Physical development includes strength, coordination, endurance, flexibility, balance and motor competence. Cognitive development can involve decision-making, attention, problem-solving and understanding of movement. Emotional development includes confidence, emotional regulation, resilience and the ability to manage success and failure. Social development includes teamwork, communication, cooperation and respect for others.

A technologically advanced sporting environment could support some of these domains, but it could also undermine them if technology becomes overly dominant.

For example, an AI system may accurately identify that a child runs more slowly than peers. However, the educationally relevant question is not simply whether the child is slower. The teacher must consider whether the child enjoys running, whether the child is improving, whether confidence is increasing and whether participation is meaningful.

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Vol. 2| Issue 5 | May 2026 | pp 1-14

This distinction leads to a central principle of this paper:

The purpose of AI in children's sport should be developmental improvement rather than continuous performance measurement.

Physical literacy provides an appropriate conceptual foundation for this principle. Research conceptualizes physical literacy as incorporating physical competence together with cognitive and affective dimensions such as knowledge, motivation and confidence.

AI should therefore contribute to all three dimensions rather than focusing exclusively on physical outputs.

9. RISKS AND ETHICAL CHALLENGES

9.1 Privacy and Data Protection

Children's sports data can be sensitive. A wearable device may collect heart rate, movement, sleep or location information, while a computer-vision system may collect video or facial information. Such information can potentially reveal patterns about a child's health, behaviour and performance.

UNICEF's child-centred AI framework specifically emphasizes children's data and privacy, safety, fairness, transparency, accountability, inclusion and wellbeing.

Schools should therefore collect only data that are genuinely necessary for a defined educational purpose. Data should not be collected simply because technology makes collection possible.

9.2 Informed Consent

Consent becomes more complicated when children are involved. Young children may not fully understand how their data will be collected or used. Consequently, parental or guardian involvement may be required, but children should also receive age-appropriate explanations and opportunities to express their preferences.

Sports-AI guidance emphasizes that meaningful consent should explain what information is collected, why it is collected, who can access it and how participants can withdraw consent. For young athletes, information should be age-appropriate and involve parents or guardians.

9.3 Surveillance and Psychological Pressure

Continuous monitoring can create a feeling that children are permanently being observed. This may increase anxiety and reduce enjoyment.

The ethical literature on sports biometrics identifies surveillance, privacy, confidentiality, data security and coercion as major concerns. Research concerning wearable technologies among children similarly raises questions about consent, autonomy, identity formation and the child's right to an “open future.”

9.4 Algorithmic Bias

AI systems learn from data. If the underlying dataset is biased toward particular genders, body types, ethnic populations, sports or performance levels, the resulting system may perform poorly for children outside those groups.

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Vol. 2| Issue 5 | May 2026 | pp 1-14

This is especially problematic because children develop at different rates. An algorithm that assumes a single developmental trajectory may incorrectly categorize normal variation as a performance problem.

9.5 Commercial Exploitation

Children's sporting data could have commercial value. Technology companies, sports organizations, advertisers or other third parties may be interested in behavioural or performance information.

A child should not become a source of commercially exploitable biometric data simply because participation in a school sports program requires the use of a particular technology.

9.6 Digital Inequality

AI-enabled sport requires devices, connectivity, trained staff and technical infrastructure. Wealthier schools may be able to provide sophisticated technology while under-resourced schools may not.

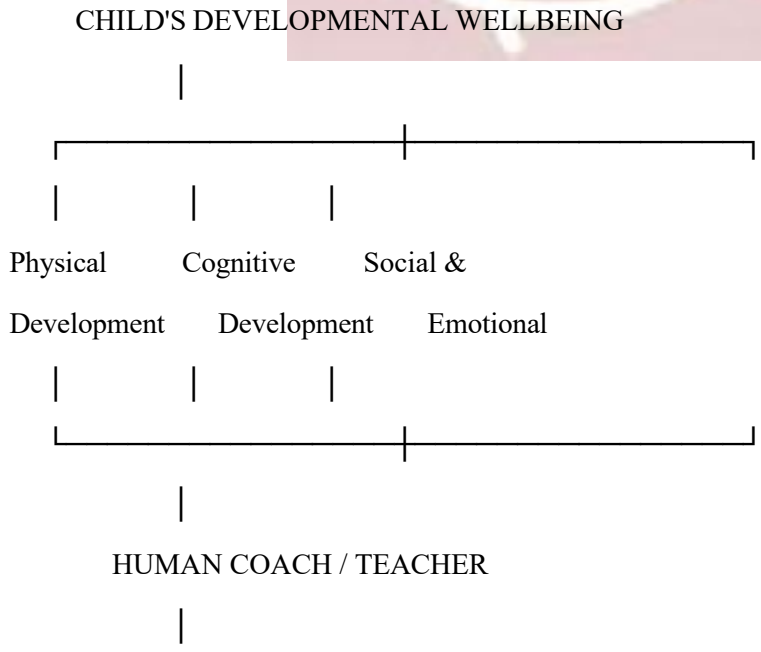
This could create a two-tier physical education system in which some children receive highly individualized technological support while others receive limited access to quality sports facilities and trained personnel.

Technology should therefore complement investment in teachers, coaches, playgrounds, sports equipment and safe spaces for physical activity—not replace them.

10. HUMAN-CENTRED AI FRAMEWORK FOR PHYSICAL EDUCATION

This paper proposes a Human-Centred AI-Enhanced Physical Education Framework based on five interconnected principles.

Figure 2. Proposed framework



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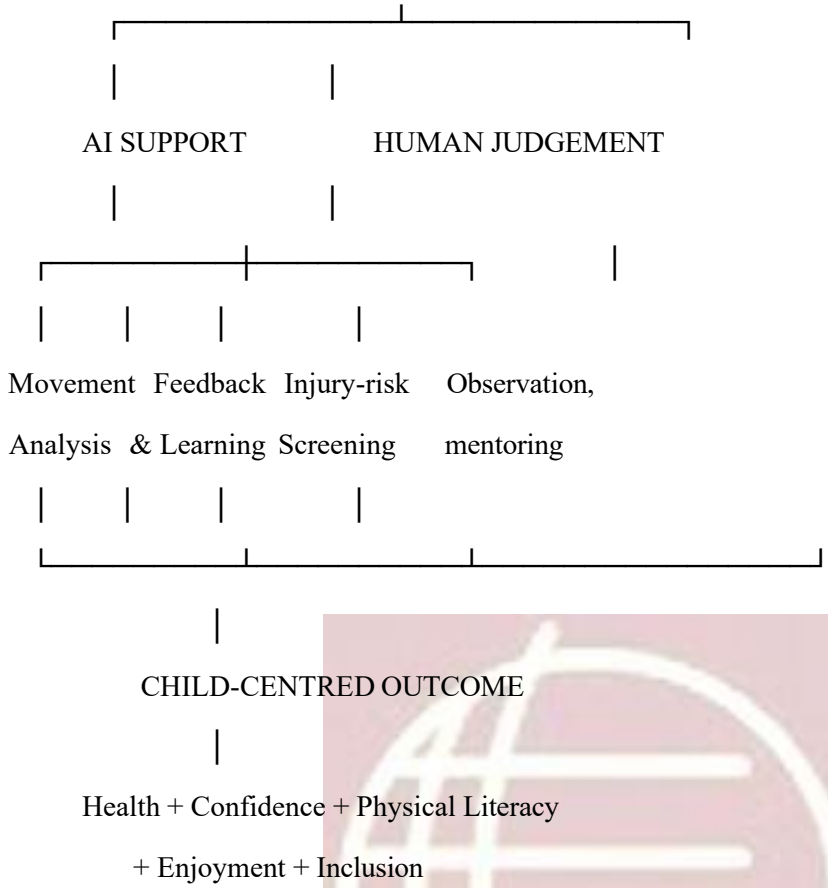
Global E-Journal of Social Scientific Research
Vol. 2| Issue 5 | May 2026 | pp 1-14



The first principle is human oversight. AI should provide information and recommendations, while teachers, coaches, parents and appropriately qualified professionals retain responsibility for decisions affecting children.

The second principle is developmental appropriateness. AI systems should be designed according to children's ages, abilities and developmental stages rather than simply adapting systems designed for adults.

The third principle is data minimization and protection. Only necessary data should be collected, and retention and access should be strictly controlled.

The fourth principle is equity and inclusion. AI should increase opportunities for participation rather than create technological advantages for already privileged groups.

The fifth principle is child wellbeing. Enjoyment, confidence, social participation and healthy development should remain more important than algorithmic performance scores.

11. AI LITERACY, DIGITAL LITERACY AND PHYSICAL LITERACY

The future of physical education should not simply teach children how to use technology. It should teach them how to understand technology.

AI literacy should help children understand that AI systems make predictions based on data and that predictions can be wrong. Children should learn that a performance score is not a measure of their

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Vol. 2| Issue 5 | May 2026 | pp 1-14

personal worth.

Digital literacy should help children understand privacy, passwords, consent, data sharing, online behaviour and responsible technology use.

Physical literacy should develop confidence, competence, motivation and understanding of movement.

Together, these three forms of literacy could create a more balanced model:

Physical Literacy + Digital Literacy + AI Literacy = Future-Ready Physical Education

This approach is consistent with UNESCO's human-centred guidance for AI in education, which emphasizes human capacity, privacy, age-appropriate use, ethical validation and meaningful educational purposes. UNICEF similarly emphasizes preparing children for present and future AI developments while protecting their rights and wellbeing.

12. PROPOSED SCHOOL IMPLEMENTATION MODEL

Schools considering AI-enhanced sports should begin with a clear educational problem rather than a technology purchase. For example, the problem may be low physical activity, difficulty providing individualized feedback, limited teacher observation capacity or barriers to participation for children with disabilities.

Once the problem is defined, the school should identify whether AI is actually necessary. If a problem can be solved through additional coaching, better equipment or improved scheduling, AI may not be the appropriate intervention.

Where AI is appropriate, implementation should begin with a limited pilot involving informed consent, teacher training and clearly defined objectives. The pilot should evaluate not only performance outcomes but also children's enjoyment, participation, confidence, wellbeing, privacy and perceptions of surveillance.

Schools should also establish a data-governance policy before collecting children's biometric or behavioural information. The policy should define what data are collected, where they are stored, who can access them, how long they are retained and when they are deleted.

Finally, the technology should be evaluated periodically. A system that improves performance but decreases enjoyment or participation should not automatically be considered successful.

13. FUTURE RESEARCH GAPS

Future research needs to move beyond the question of whether AI can analyse children's sporting performance and examine whether AI actually improves children's developmental outcomes.

Longitudinal studies are particularly important. Researchers should examine whether AI-supported physical education produces sustained improvements in physical activity, physical literacy, confidence and participation over several years rather than only measuring short-term performance changes.

There is also a need for research specifically involving children rather than extrapolating from adult

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Vol. 2| Issue 5 | May 2026 | pp 1-14

sports and educational environments.

Another major gap concerns children with disabilities. AI has considerable potential to support adaptive physical education, but there is insufficient evidence regarding which technologies genuinely improve inclusion and which simply introduce additional complexity.

Research is also needed on the psychological consequences of continuous performance monitoring. Studies should examine whether children who receive constant AI-generated feedback become more motivated or instead experience anxiety, comparison, perfectionism or reduced enjoyment.

The validation of AI models represents another important research priority. Recent sports-injury research continues to identify problems involving external validation, methodological heterogeneity and generalizability. A model performing well on its original dataset cannot automatically be assumed to work equally well in another school, population or developmental group.

Finally, research should examine the governance of children's sports data. Future studies should investigate who owns children's performance and biometric information, whether parents and children can withdraw data, how long information should be retained and whether commercial organizations should be permitted to use such information.

14. PROPOSED FUTURE RESEARCH AGENDA

A future empirical research programme could develop and test an AI-enhanced physical education intervention across schools. A representative study could compare schools using conventional physical education with schools using carefully regulated AI-assisted feedback.

The research could measure changes in physical activity, physical-literacy scores, attendance, motivation, confidence, enjoyment and injury incidence. Qualitative interviews with children, teachers and parents could examine whether participants perceive AI as supportive or intrusive.

A particularly valuable research model would be a mixed-method longitudinal study conducted over one academic year or longer. Quantitative measures could determine whether measurable outcomes improve, while interviews and focus groups could identify how children experience the technology.

Such research would help answer a question that current technological enthusiasm often overlooks: Does more information actually produce better childhood development?

15. DISCUSSION

The evidence reviewed in this paper suggests that AI represents neither an inherently positive nor inherently negative development for children's sport. Its effects will depend primarily on the purpose for which it is introduced, the design of the system, the quality of the underlying data, the governance framework and the role assigned to human professionals.

The strongest argument for AI in children's sport is personalization. Teachers and coaches often work

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Vol. 2| Issue 5 | May 2026 | pp 1-14

reduced to measurable variables. Speed, heart rate, distance, acceleration and movement scores provide information, but they cannot fully capture enjoyment, friendship, confidence, resilience, creativity or the meaning that a child attaches to sport.

This distinction is essential. The purpose of children's sport is not simply to create better measurements. It is to create healthier and more capable human beings.

The WHO recommendation of approximately 60 minutes of moderate-to-vigorous physical activity per day provides an important public-health benchmark, while the global finding that more than 80% of adolescents fail to meet this recommendation demonstrates the scale of the challenge. AI should therefore be judged partly on whether it helps increase participation in meaningful physical activity.

If AI causes children to spend more time interacting with screens, comparing scores or worrying about performance, its use may become counterproductive. Conversely, if technology helps a previously inactive child discover an enjoyable activity, gives a teacher better insight into individual needs or enables a child with a disability to participate more fully, its educational value may be considerable.

The appropriate future is therefore neither technology-free physical education nor technology-dominated physical education. It is human-centred, technology-supported physical education.

16. CONCLUSION

Artificial intelligence is likely to become an increasingly important component of sports and physical education. Its capabilities in movement analysis, personalized feedback, performance monitoring, accessibility and injury-risk assessment create genuine opportunities for improving children's sporting experiences. However, these opportunities must be considered within the broader developmental purpose of childhood sport.

The literature demonstrates that physical activity is essential to children's physical, cognitive and mental wellbeing, yet global physical inactivity remains extremely high. At the same time, AI and wearable technologies are expanding the ability of schools and sports organizations to collect and analyse information about young people. This combination creates both an opportunity and a responsibility.

The central argument of this paper is that AI should augment rather than replace human coaching, teaching and parental guidance. Technology can identify patterns, provide feedback and support decision-making, but it cannot fully understand the emotional, social and developmental context of a child.

The future of physical education should therefore be built around a balance between technological innovation and human development. Children should be taught not only how to move and play, but also how to understand data, question algorithms and protect their digital identities. Physical literacy, digital literacy and AI literacy should become interconnected elements of future education.

Most importantly, children should not become passive objects of technological measurement. They should remain active participants in decisions concerning how technology is used in their sporting

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Global E-Journal of Social Scientific Research
Vol. 2| Issue 5 | May 2026 | pp 1-14

The ultimate measure of AI-enhanced sport should not be whether a child runs faster, jumps higher or produces a better statistical profile. Its success should be measured by whether children become more physically active, more confident, more competent, more socially connected and more capable of enjoying physical activity throughout their lives.

AI has the potential to become a powerful tool for this objective. But the technology must remain the servant of child development—not its master.

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