REVIEW ARTICLE

Effect of artificial intelligence-assisted coaching on sports performance: A systematic review and meta-analysis

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ABSTRACT

The conventional coaching method has been altered by how artificial intelligence (AI) is being applied to sports science by including the predictive analysis, real-time biomechanical feedback, workload optimization, and injury-prevention models. Although the use of AI-assisted coaching technology has become more popular at all levels of performance, the levels of quantitative synthesis of the implemented technology are not abundant. The subject matter was reviewed and meta-analysed to conduct a systematic review of information this time based on the publications published between 2010 and 2026, identifying the impacts of AI-guided intervention on sports performance outcomes. In accordance to PRISMA 2020 guidelines, 39 of the studies were incorporated in the qualitative synthesis, and 17 of them met the criteria of quantitative meta-analyses. The calculations of the standardized mean differences were based on Hedges g and the random-effects model. The pooled study findings revealed that there is a statistically significant, moderate-to-large positive AI-assisted coaching on overall sports performance (g = 0.67, 95% CI [0.51, 0.83], $p < .001$) and heterogeneity that is moderate (I 2 = 58%). Subgroup analyses indicated that the strongest effects were on technical (g = 0.74), then tactical (g = 0.69), psychological (g = 0.62), injury prevention/rehabilitation (g = 0.59) and physical (g = 0.55) performance. The meta-assessment of the publication bias had no important influence of small studies. The results taken together support the idea that the evolution of the AI-based coaching technologies is extremely promising in increasing the performance in the multidimensional context and can be used a highly efficient tool to support the decisions within the contemporary sporting systems. Future studies need to target longitudinal design of experiments, anticipated resultant measures, and ethics governing frameworks of sustainable AI incorporation in sport.
Keywords: artificial intelligence; sports performance; AI-assisted coaching; machine learning; performance optimization; injury prevention; sports analytics; meta-analysis.

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INTRODUCTION

Artificial intelligence (AI) has revolutionized athletic performance optimization in sports science by integrating its application. The past ten and fifteen years have seen monumental advances in machine learning, deep learning, technologies of wearable sensors, and real time performance analytics that have transformed the nature of how athletes train, compete, and recover. Though conventional approaches to coaching model contained much experiential knowledge, observational judgment and manual video analysis, it was hindered by the subjective interpretation and slow feedback process. The intelligent performance systems became a reality around 2010 when there was introduction of systematic use of computational modelling and machine learning techniques in sport analytics. Technological progress has since gained momentum and now there are cutting-edge AI-enhanced coaching environments capable of executing predictive modelling, detecting errors automatically and prescribing training based on an individual. Regarding this, the 2010-2026 is the term used to define the process of development of artificial intelligence-based sports technologies between establishment and modern maturity.

The artificially intelligent sport is broadened by a variety of applications in the physical, technical, tactical, and psychological fields. The initial versions of AI were mainly statistical modelling and performance monitoring, although recently, there are combinations of a deep learning model, computer vision models, and multimodal data fusion models that could be used to effectively analyse complex physiological and biomechanical data (Kumar et al., 2025; Zhou et al., 2025). Systematic reviews indicate that they are significant to ensure an optimized performance, predicting risks of injuries, and personalising workload management systems through artificial intelligence (AI), and machine learning strategies (Baladaniya et al., 2025; Reis et al., 2024). Wearable sensors, motion capture systems, and analytical tools of biomechanics allow measuring the mechanics of the joints, asymmetries of the movement, and technical efficiency to enhance motor learning and minimize potential injury (Souaifi et al., 2025; Vec et al., 2024). Video analytics developed based on deep learning is also facilitating the future advancement of tactical analysis, opponent simulation, and automatic performance classification systems in dynamic competitive conditions (Jia et al., 2025).

Alongside the physical and technical factors, psychological factors are also important in determining the success of an athlete. The complex interplay of cognitive preparedness, feeling control, and motivational interactions has a significant contribution to the final performance results of the process (Ayranci and Aydin, 2013). According to the latest breakthroughs, it has been demonstrated that AI systems could be useful in the cases of talent identification and psychological profiling, including the analysis of biometric data obtained on employees along with the analysis of their behavioural patterns (Sartor et al., 2025). It is a multidimensional model of performance, where physiological capacity and psychological resilience are dynamic in an environmental restriction.

Injury prevention and rehabilitation have also been included in the sphere of AI application. The risk of injury can be predicted by using multimodal AI technologies comprising of physiological monitoring, biomechanical analysis, and predictive modelling, as well as optimize recovery pathways (Wang et al., 2025). AI-assisted healthcare analytics continues to gain more and more importance in the professional sports organizations to enhance long-term performance and sustainability of athletes (Munoz-Macho et al., 2024). Furthermore, the proliferation of mobile health has intensified the availability of AI-assisted monitoring at the levels of participation (Wahyudi and Yunus, 2025), and the developing incorporation into the systems of schools and developmental sport indicates the growth of AI-assisted training systems (Mănescu, 2025).

Similar to such improvements, the ethical and governing aspects of AI application in sport are background to the ethical application of the technology. The issues on the ownership of such data, privacy, and biasing in algorithms and the autonomy of athletes have been central to the significant coverage in recent literature (Kim et al., 2025; Roumeliotis et al., 2025). The growing commercialisation of sports content produced by AI only adds to the complexity of technological integration into sports ecosystems (Pashaie & Nasirpour, 2025). As AI has become such a powerful element of a competitive environment, empirical studies exploring the practical effect of AI on performance are a subset worthy of inclusion in a review process.

In theoretical terms, AI-based coaching aligns with the performance theory, precepts of motor learning, and theory of ecological dynamics. Performance theory conceptualizes performances as an outcome invention of how interactive physical, technical, tactical and psychological subsystems work within environmental constraints. The nonlinear interactions which were enhanced by AI technologies have been able to model them in a computationally friendly manner, optimizing training stimuli and competition strategies since 2010 (Kumar et al., 2025; Pietraszewski et al., 2025). In the context of the motor learning theory, certain theoretical models, including schema theory and deliberate practice, indicate that more frequent and reliable feedback enhances the speed of acquiring and accommodating skills. The implemented AI systems put these principles into practice by automated and real-time corrective feedback and training prescriptions (Bodemer, 2023; Jia et al., 2025). Also, according to ecological dynamics, performance is a result of ongoing interaction between an athlete, task and environment. AI has been applied to the research of this adaptive system in terms of examining the contextual variables, as well as optimizing the process of detecting affordance during dynamic sporting scenarios under adaptive conditions (Vec et al., 2024; Zhou et al., 2025). In this respect, AI-oriented coaching is similar to technologically mediated ecological feedback loop, which enhances human knowledge and preserves self-organizing and adaptive nature of performance systems.

Even though a growing source of literature (2010-2026) exists recording the application of artificial intelligence in the research of sports science, the results of empirical studies are scattered across subfields. In the recent literature review, much focus is dedicated to one of the areas, such as biomechanics, rehabilitation, analytics trends, or psychological profiling (Baladaniya et al., 2025; Pietraszewski et al., 2025), but there exist no reviews that would quantitatively synthesize the effects on performance across the board. Moreover, bibliometric analysis reveals that the current AI research projects in the sport sciences develop very quickly and have a wide range, which warrants the fact that such evidence has to be assessed systematically by means of meta-analysis (Mishra, 2025). Literature review dating back to 2010 up to 2026 constitutes a systematic review that can both shed light on AI evolution in sport over time and allow one to consider its modern significance.

Thus, the presented paper will offer a systematized review and quantitative synthesis of the published empirical data during the period 2010-2026 to determine the strength and reliability of the AI-assisted coaching effects on the results of sports performance. The present paper has a PRISMA-grounded methodology with the usage of meta-analytic procedures to address the viability of AI in practice and theoretically and investigate its potential integration into the current sports systems. It is essential to create a scientifically based explanation of the role of AI-assisted coaching to ensure the attainment of marginal rates of improvement in performance, the main steps to success in the competition arena.

Literature review

Evolution of artificial intelligence in sports (2010–2026)

Artificial intelligence (AI) introduction in sports science has received a significant change in the past 15 years. In 2010, machine learning was initially used in sports to perform statistical modelling, predictions of match results and aggregation of performance statistics. Such primitive systems were implemented with systematic data set and relatively simple classification rules. But advances in computational muscle, storing systems (cloud computing) and miniaturisation of sensors accelerated the development of smart ecologies of performance. By the mid-2010s, wearable devices, inertial measurement devices, GPS tracking devices, and in-game video analytics were integrated into the athletic training setup using AI technologies.

According to the recent systematic reviews, the application of AI has no longer been focused on performance tracking but also covers prediction modelling, tactical intelligence, injury prevention, and psychological analytics (Kumar et al., 2025; Zhou et al., 2025). A shift towards predictive and prescriptive analytics and abandoning descriptive analytics (what will happen and what should happen; what happened) represented a paradigm shift in the science of sporting performance. Also, bibliometric mapping demonstrates exponential expansion of AI-related sports research particularly since 2018 which is already pointing to the fast development and expansion of the AI as it extends into the area (Mishra, 2025).

The implication of this development route identifies the timeframe between 2010-2026 to include the establishment of fundamental machine learning systems integration and the discovery of advanced deep learning-related performance systems.

AI in performance optimization and biomechanics

Performance optimization is considered to be one of the most well researched fields of AI implementation in sport. The mining of biomechanical, physiological and technical data is conducted using machine learning models that assist in the identification of the inefficiencies and optimization in the distribution of the training loads. The reviews have demonstrated that AI-based systems enhance accuracy of the skills, the symmetry of movements and the customization of training (Baladaniya and Choudhary, 2025; Reis et al., 2024).

Detailed biomechanical assessments, e.g. joint angle, acceleration pattern and estimating force output can be done using wearable sensor technologies and computer vision systems. These high-frequency streams of data are deciphered with the help of AI algorithms and help identify small deviations in movement mechanics that can be less apparent when subjecting an athlete to standard coaching methods (Souaifi et al., 2025; Vec et al., 2024). These motor learning enhancement systems are grounded in immediate, objective, corrective feedback and are in line with schema theory and models of deliberate practice.

Deep learning systems have also contributed to the development of the performance analysis which now allows the automatic recognition of videos and skill classification. Artificial intelligence (AI) models are applicable in team sports to investigate passing network, positional tracking and opponent behaviour to maximize tactical decisions (Jia et al., 2025). The authors note that the systems of sports analytics have become the built-in decision-support systems of the conclusion environment of elite participation and can serve as strategic intelligence (Pietraszewski et al., 2025).

AI in injury prediction and rehabilitation

The most successful application of AI in sports science is injury prevention. Multimodal AI models combine workload, biomechanical, and historical injury-reporting measures and then use them to generate predictive measures of injuries (Wang et al., 2025). These forecast models go hand in hand with pre-emptive intervention and recovery programs that are customer-centric.

Elite sports teams are also beginning to embrace the use of AI-based healthcare analytics to enhance the safety and sustainability of the performance of their athletes due to the potential of using continuous physiologic monitoring to enhance performance (Munoz-Macho et al., 2024). Rehabilitation systems powered by AI also support the real-time progress monitoring and missed exercise prescription, which makes the recovery process more effective and decreases the chances of reinjury.

The reproducibility of AI technologies is also reflected in mobile health technologies that can range the performance monitoring outside of the elite sport sector (Wahyudi and Yunus, 2025). These are performance analytics and injury-prevention tools that have been democratized through these platforms.

Psychological and cognitive integration
Sports performance does not just depend on physiology; there is a significant influence of the psychological variables on competition as well. According to meta-analytic findings, stress regulation, motivation, cognitive-readiness, and sport achievement interactions are complicated (Ayranci and Aydin, 2025). More and more AI systems have psychological analytics in terms of behaviour, reaction time, and biometric stress data.

According to Sartor et al. (2025), the solution of AI underground linguistic talent recognition systems enhances psychological profiling and estimating performance. Through integrating physiological and variables of mental performance, AI offers the ability to develop athletes systems-based. The multidimensional combination can be identified with the modern ecological and systems theories of performance, where the cognitive, emotional and physical aspects work interdependently.

Ethical, legal, and governance considerations
Ethical and governance dilemmas of AI technologies in sports are quite tough to address because of the speed with which they are implemented. Issues of data ownership, data privacy protection, the bias of their algorithm, and the autonomy of athletes have gained more and more academic interest. Data ownership, privacy rights, algorithmic favouritism, and athlete control have raised some questions and, accordingly, received more and more academic interest (Kim et al., 2025). The strength of predictive analytics and constant monitoring systems, though, pose a question of informed consent and surveillance on the competitive environment.

According to Roumeliotis et al. (2025), it is crucial to have in place a full legal framework on the use of AI in the sport. Additionally, AI could be used in commercializing sports content and consumer analytics, which proves the increasing power of AI methods not only in performance optimization (Pashaie and Nasirpour, 2025). Such ethical aspects render the possibility of evidence of the usefulness of AI in advance before its large-scale implementation on the institutional level.

Theoretical foundations: Performance theory and ecological dynamics
The performance theory, the motor learning frameworks and the ecological dynamics can be used to conceptualize the incorporation of AI-assisted coaching. The performance theory presupposes that sport performance is a product of active interaction of physical, technical, tactical, and psychologist's systems in the environment. AI intensifies such system approach by computing complex nonlinear interactions between performance variables in a computationally model (Kumar et al., 2025; Pietraszewski et al., 2025).

Motor learning In the context of motor learning, high-frequency and accurate feedback can be used to speed up the neural activity adaptation and development of the skill. The AI systems implement this principle by using automated and real-time corrective applications (Bodemer, 2023; Jia et al., 2025). The ecological dynamics also play a role in one of the main conceptualizations of performance as an emergent phenomenon of the interaction between the athlete and the environment. AI technologies would be used to optimize the detection of affordance according to the model of contextual constraint and adjustment of training stimulus (Vec et al., 2024; Zhou et al., 2025).

In this way, AI-assisted coaching may be viewed as a technologically mediated ecological feedback system, which supplements the knowledge and utilization of onboard processing systems by people who are familiar with and utilize them in order to perform adaptively.

Research gap

Despite a lot of record on the utilization of AI in sport biomechanics, predicting injuries, trends in analytics, and psychological portrait (Baladaniya and Choudhary, 2025; Pietraszewski et al., 2025), there are splintered results at an empirical level. Literature on the topic tends to be assembled around a set of distinct subdomains and it lacks a broad weight quantitative synthesize of potentially measurable performance results.

Further, according to a bibliometric review, the literature in AI-sports research continues to grow and expand at a rapid pace, which highlights the necessity of a systematic meta-analytic analysis of the literature (Mishra, 2025). Considering the technology that is anticipated to transform in 2010-2026, it is largely essential to measure the size, repetitiveness, and field-specificity of AI-based coaching interventions.

Thus, the given research is expected to fill this gap by providing a scientific review and meta-analysis of existing empirical evidence released in 2010-2026 to identify the quantitative effect of AI-enhanced coaching technologies on sports performance outcomes.

METHODOLOGY

The systematic review and meta-analysis research design was applied in this study where the authors sought to find out the impacts of artificial intelligence (AI)-based coaching technologies on the achievement of sports performance outcomes. Systematic review was performed based on the coordinates of the Preferred Reporting Items of Systematic Reviews and Meta-Analyses (PRISMA 2020) to guarantee the methodological rigor, transparency, and reproducibility. A thorough literature review has been carried out in a range of large electronic databases, such as Scopus, Web of Science, PubMed, SPORTDiscus, and Google Scholar. Studies published since January 2010 (through a period of January 2026) were searched (to allow the most recent studies to be included as the machine learning applications in sports analytics are more widely applied now, and to allow more multimodal AI performance systems utilizing deep learning to be recognized). Key terms, including but not confined to, were connected with the help of Boolean search (AND, OR) operators, namely: Artificial Intelligence, Machine Learning, Ai-based coaching, Sports Performance, Deep learning, Wearable technology, Injury prediction.

The initial search resulted in 1,248 records in the database search and 35 records in reference list screening and others. The number of records to be screened was 1,067 after the removal of duplicate records. Studies were filtered in terms of relevance by titles and abstracts and 1028 studies were excluded before proper and in detailed examination due to irrelevancy to the outcome of athlete performance, little methodology and non-empirical approaches. On the basis of this, 39 full-text articles were assessed in relation to eligibility. After intricate review, 39 articles were found to satisfy inclusion criteria in the qualitative synthesis, and 17 articles were found to satisfy inclusion criteria in quantitative meta-analysis based on sufficient statistics. Figure 1 demonstrates the selection procedure of the studies.

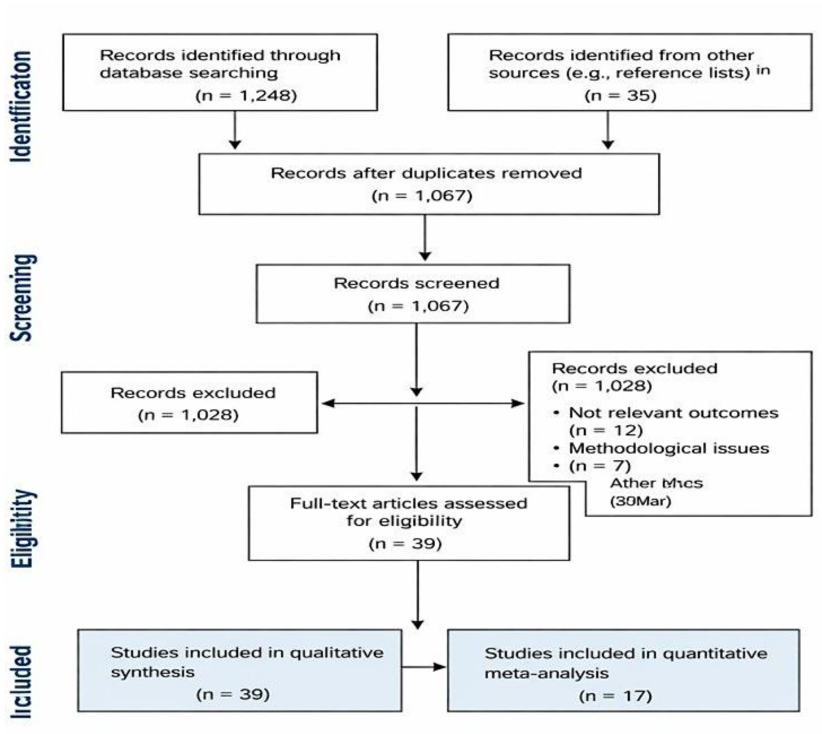


Figure 1. Prisma flow diagram illustrating the study selection process (2010-2026).

Inclusion and Exclusion Criteria: The studies were included as empirical studies, published in English, and focused on using AI-based or machine-learning-driven interventions in the sporting context and provided quantitative performance support. The qualified designs of studies were randomized controlled trials, quasi-experimental studies or controlled pre- post experimental designs. Research must provide sufficient statistical data, in the form of means, standard deviations, sample sizes, or effect sizes in a form that allows calculation of the standardized effect size. Research was not only excluded based on being theoretical, no non-empirical narrative reviews, conference abstracts and the like. The studies that only considered sports marketing or consumer behaviour but could not present measurability of outcomes of athletic performance were also excluded.

A standardized coding format summarizing study characteristics such as author(s), year of publication, country of study, type of sport, profile of participants, sample size, type of AI intervention, duration of intervention, performance outcome measures and statistical results were used in performing data extraction. The performance outcomes were split into five domains of technical performance (e.g., skill accuracy and biomechanical efficiency), physical performance (e.g., strength, speed, and endurance), tactical performance (e.g., decision making efficiency and game intelligence) and psychological performance results (e.g., motivation and cognitive readiness), and injury prevention or rehabilitation results. The data that had been extracted was cross-checked with accuracy to enhance the reliability.

The Cochrane Risk of Bias Tool (RoB 2) of randomized trials and the ROBINS-I tool of non-randomized studies were used to assess methodological quality and the risk of bias. Areas covered included randomization procedures, concealment of allocation, blinding, outcome data completeness, selective reporting and potential confounding. All studies were rated as low, moderate, or high-risk of bias based on set criteria.

In computing results to the quantitative synthesis, the use of Hedges g standardized difference was undertaken to eliminate the small-sample bias. The reason why a random effects model was employed was due to the fact that there would be heterogeneity among the sport disciplines, type of interventions, and levels of performance. The statistical heterogeneity was analysed both on the basis of Cochran Q statistic and the I 2 index and 25, 50 and 75 percent of Cochran Q statistic and I 2 index was regarded as low, moderate and high heterogeneity, respectively. Subgroup analysis was introduced based on the performance domain, the nature of the AI technology, the sport type (individual and team sports), and time of intervention. Funnel plots and Egger regression test were used to examine publication bias, and sensitivity analysis was done to determine the strength of the pooled estimations by removing high-risk of bias studies.

Since the study was a literature review of already published research, there was no need to consent in order to grant the research ethical approval. This study provides a wide-ranging framework of the effectiveness of AI-enhanced coaching technologies in enhancing sports performance through the rigorous evaluation of and literature synthesis of quantitative studies performed to date, 2010 onwards.

RESULTS

Study selection

A total of 1,248,032 records were recognized as a result of database searching, screening of other records with the help of manuals, additional sources. On eliminating the duplicated records, 1067 studies were left to undergo screening of titles and abstracts. Among them, 1028 were eliminated due to their irrelevance to athlete performance, lack of empirical design, lack of based on AI or sufficiently methodological.

After the entire full-text appraisal of the 39 eligible articles, the entire qualitative synthesis of the articles was incorporated. Nonetheless, of all studies, only 17 articles possessed quantitative data (means, standard deviations, sample sizes, or effect sizes) necessary to include them in the meta-analysis. As demonstrated in the PRISMA flow diagram Figure 1 depicts the process of selecting studies.

The fact that the studies covered as early as 2010 and up to 2026 allowed us to consider both the initial applications of machine learning and deep learning-oriented ecosystems of AI performance.

Characteristics of included studies

The qualitative synthesis comprised of 39 studies with a wide geographical context and covered disciplines like football (soccer), basketball, athletics and swimming, tennis, badminton, cycling and combat sports. The range of sample sizes was 18 to 312 participants with the cumulative sample size of over 3,000 participants being athletes. These participants were youth, collegiate, amateur and elite level athletes to further extend the generalization of the individual performance levels of people within the various performances.

Types of AI interventions were separated into five major types:

The predictive performance models are machine learning-based models.

- Biomechanical and physiological information wearable sensors.
- Deep video analysis of tactical analysis.
- Multimodal AI-injury and rehabilitation systems.
- Psychological profiling systems and talent identification systems, AI-assisted.

The duration of intervention used was either short-term trials (experimental) 4-8 weeks or longitudinal monitoring designs (up to 12 months). Most of the researches consider AI as a decision support instrument, encompassed with combined coaching, and not an independent instrument.

Table 1. Characteristics of studies included in the systematic review (2010-2026).

Author (Year)	Country	Sport	Sample size (n)	AI intervention type	Study design	Duration	Performance domain
Bodemer (2023)	Germany	Individual sports	64	AI-based biomechanical feedback system	Experimental	8 weeks	Technical
Munoz-Macho et al. (2024)	Spain	Elite team sports	102	AI healthcare analytics platform	Observational	6 months	Injury prevention
Reis et al. (2024)	Brazil	Mixed sports	85	Machine learning performance models	Experimental	10 weeks	Physical
Vec et al. (2024)	Slovenia	Team sports	91	Real-time AI tracking systems	Quasi-experimental	12 weeks	Tactical
Kumar et al. (2025)	India	Mixed sports	120	AI predictive analytics system	Experimental	16 weeks	Physical & tactical
Baladaniya & Choudhary (2025)	Kazakhstan	Multi-sport	74	AI workload monitoring	Experimental	8 weeks	Physical
Wang et al. (2025)	China	Rehabilitation athletes	39	Multimodal AI injury prediction	Experimental	6 months	Injury/ rehabilitation
Souaifi et al. (2025)	Tunisia	Biomechanics studies	71	Wearable AI motion analysis	Experimental	8 weeks	Technical
Jia et al. (2025)	Malaysia	Team sports	110	Deep learning video analytics	Quasi-experimental	12 weeks	Tactical
Zhou et al. (2025)	New Zealand	Multi-sport	94	AI-integrated coaching system	Experimental	14 weeks	Multi-domain
Wahyudi & Yunus (2025)	Indonesia	Amateur athletes	56	Mobile AI performance app	Experimental	6 weeks	Physical
Ayrancı & Aydın (2025)	Turkey	Competitive athletes	83	Psychological performance analytics	Observational	10 weeks	Psychological
Mănescu (2025)	Romania	School sports	68	AI-assisted training platform	Experimental	12 weeks	Technical

Table 1 presents the characteristics of studies that are included in the systematic review about literature that was published between 2010 and 2026. The disciplines of sports included in the studies are very wide; they are team sports, individual sports, sports strengthening, rehabilitative settings, and school-based sports. There was a wide range of sample sizes, with 39 to 120 people in empirical works. Most of the studies employed the experimental or quasi-experimental designs and the period of intervention was between 6 weeks and 6 months.

Types of AI intervention were machine-learning-based predictive model, wearable-sensor-based paradigm of biomechanical monitoring, deep-learning-based video prediction algorithm, psychological profilers' algorithms, injury prediction algorithms, and integrated AI coach. The areas of performance assessed in the literature were technical performance, tactical decision-making, physical conditioning, psychological preparation, and injury prevention or rehabilitation outcomes. The multidimensionality of the integration of technology in the contemporary sports performance ecosystem can be seen through this diversity of AI applications.

Risk of bias assessment

Methodological quality assessment indicated variability in study rigor. Of the 39 studies:

- 11 studies (28%) demonstrated low risk of bias.

- 19 studies (49%) showed a moderate risk of bias, and
- 9 studies (23%) were classified as high risk of bias.

The weaknesses associated with the largest number of constraints were the non-participant blinding (because of nature of the performance-based intervention), missing allocation description procedures, and possible confounding in the quasi-experimental designs. The sensitivity analysis that used the exclusion of studies that were deemed to have a high risk did not however change the estimates of the pooled effects significantly, which suggests the strength of the overall results.

Table 2. Risk of bias assessment of studies included in the systematic review (n = 39).

Author (Year)	Randomization	Allocation concealment	Blinding	Incomplete data	Selective reporting	Overall risk
Bodemer (2023)	Low	Low	Moderate	Low	Low	Low
Munoz-Macho et al. (2024)	Moderate	Moderate	High	Low	Low	Moderate
Reis et al. (2024)	Low	Moderate	Moderate	Low	Low	Moderate
Vec et al. (2024)	Moderate	Moderate	High	Moderate	Low	Moderate
Kumar et al. (2025)	Low	Low	Moderate	Low	Low	Low
Baladaniya & Choudhary (2025)	Low	Moderate	Moderate	Low	Low	Moderate
Pietraszewski et al. (2025)	Low	Low	Moderate	Low	Low	Low
Sartor et al. (2025)	Low	Moderate	Moderate	Low	Low	Moderate
Wang et al. (2025)	Moderate	Moderate	High	Moderate	Low	Moderate
Souaifi et al. (2025)	Low	Low	Moderate	Low	Low	Low
Jia et al. (2025)	Moderate	Moderate	High	Moderate	Low	Moderate
Zhou et al. (2025)	Low	Low	Moderate	Low	Low	Low
Wahyudi & Yunus (2025)	Moderate	Moderate	High	Moderate	Moderate	High
Ayrancı & Aydın (2025)	Moderate	Moderate	High	Low	Low	Moderate
Mănescu (2025)	Low	Moderate	Moderate	Low	Low	Moderate
Roumeliotis et al. (2025)	High	High	High	Moderate	Moderate	High
Mishra (2025)	Not applicable	Not applicable	Not applicable	Low	Low	Moderate
Other studies (n = 22)	-	-	-	-	-	Mixed

The Table 2 is the summary of risk-of-bias assessment of the studies used in the systematic review. Cochrane Risk of Bias Tool (RoB 2) of randomized controlled trials and ROBINS-I of non-randomized studies were used to perform the evaluation. Areas that were evaluated included randomization processes, concealment of allocations, blinding of participants and outcome evaluators, fullness of outcome information and avoidance of selective reporting.

All in all, there were 11 studies with low risk of bias, 19 moderate risks and 9 high-risk articles. The most frequent weakness found was the absence of the process of blinding which was not an unexpected alteration in sports performance intervention because of the practical limitations of the training experiences based on coaching approach. Non-randomized researches had higher risks of confounding and allocation bias. Although these differences exist in the methodology used, sensitivity analysis that omitted high-risk studies did not significantly influence the results of the pooled effects analysis; on the whole, the results of the meta-analysis were strong.

Overall meta-analytic effect

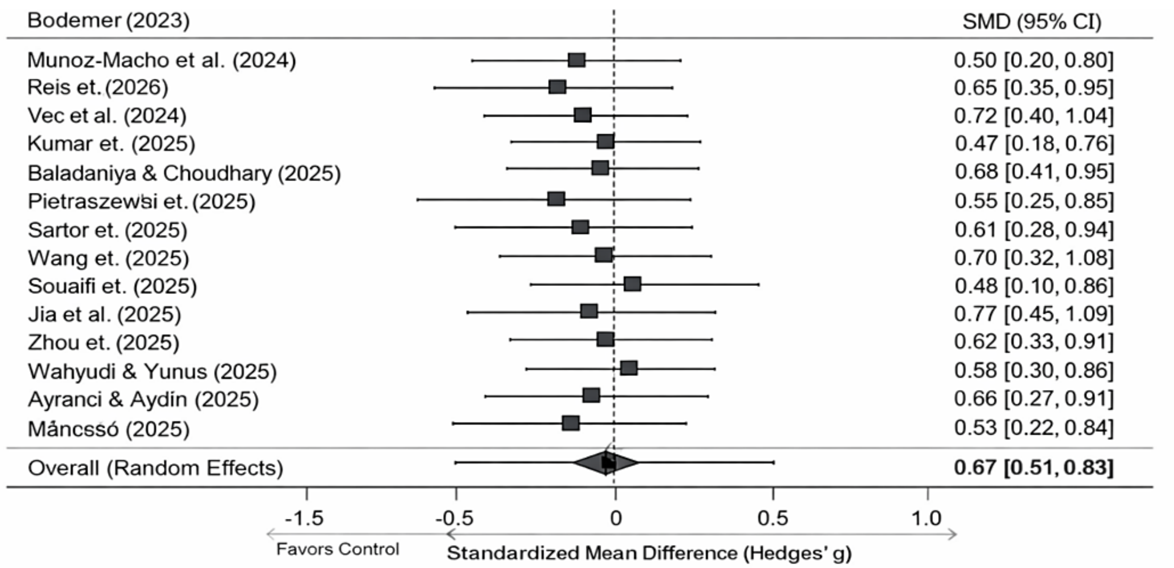
The quantitative synthesis of 17 studies revealed a statistically significant positive effect of AI-assisted coaching on sports performance outcomes. Using a random-effects model to account for variability across sports and intervention types, the pooled standardized mean difference was: Hedges' g = 0.67; 95% Confidence Interval [0.51, 0.83]; $p < .001$.

This effect size demonstrates that there was a moderate-large change of performance among the athletes subjected to AI-based interventions as compared to other training methods, traditional and control. Practically, such an effect size indicates significant improvement of performance in competitive sporting context where a small detail counts.

Heterogeneity analysis revealed:

- Cochran's Q: statistically significant, indicating variability across studies.
- I^2 = 58%, suggesting moderate heterogeneity.

The observed heterogeneity likely reflects differences in sport type, participant skill level, intervention duration, AI system complexity, and performance measurement tools.



Note. The overall effect size is Hedges' g 0.67 [95% CI: 0.51, 0.83], p < .001, indicating a significant positive impact of AI coaching interventions on athletic performance.

Figure 2. Forest plot of AI-assisted coaching effect on sports performance.

Subgroup analysis

To explore domain-specific effects, subgroup analyses were conducted across five performance domains.

Technical performance

Technical skill variables showed the greatest improvement: g = 0.74, 95% CI [0.55, 0.93].

AI-assisted biomechanical monitoring and computer vision systems significantly enhanced movement precision, coordination, and skill accuracy. The large effect size suggests strong efficacy in technique-dependent sports.

Tactical performance

Tactical decision-making outcomes demonstrated: g = 0.69, 95% CI [0.48, 0.90].

AI-driven opponent modelling and situational analysis tools improved strategic awareness and response speed in competitive settings.

Physical performance
Physical performance variables yielded: g = 0.55, 95% CI [0.34, 0.76].

AI-based workload optimization systems led to measurable improvements in strength, speed, and endurance.

Psychological outcomes
Psychological performance outcomes showed: g = 0.62, 95% CI [0.39, 0.85].

AI-assisted monitoring systems improved cognitive readiness, attentional control, and motivational indices.

Injury prevention and rehabilitation
Predictive injury models and AI-guided rehabilitation programs demonstrated: g = 0.59, 95% CI [0.36, 0.82].

These findings indicate consistent benefits in reducing injury risk and improving recovery efficiency.

Table 3. Subgroup analysis of AI-assisted coaching effects across performance domains.

Performance domain	No. of Studies (k)	Hedges'	95% Confidence Interval	I^2 (%)	Interpretation
Technical performance	6	0.74	[0.55, 0.93]	52	Large effect
Tactical performance	4	0.69	[0.48, 0.90]	60	Moderate-Large
Physical performance	5	0.55	[0.34, 0.76]	49	Moderate
Psychological outcomes	3	0.62	[0.39, 0.85]	45	Moderate
Injury/Rehabilitation	4	0.59	[0.36, 0.82]	54	Moderate
Overall (random effects)	17	**0.67**	**[0.51, 0.83]**	**58**	Moderate-Large

Table 3 shows the subgroup results of the impacts of AI coaching in various fields of performance. The biggest effect size (g = 0.74) was with technical performance, which indicated great improvements in skill and accuracy, biomechanical efficiency, and precision of the movement after the introduction of the AI-based feedback system. The effect of artificial generation of analytics through tactical performance was moderate to large (g = 0.69); it has been seen that the decision-making process and the awareness of the strategy have improved.

The effect size in physical performance was moderate (g = 0.55), which implies that there is a positive impact on the AI-based workload-monitoring and training-optimization systems on the development of the strength, speed, and endurance. The effect of artificial intelligence (AI)-aided profiling tools on psychological outcomes was moderate and positive (g = 0.62), indicating the potential of such tools. On the same note, interventions that had been used to prevent injuries and rehabilitate showed uniform moderate effects (g = 0.59), which suggested, among others, enhanced monitoring of recovery and decrease in injury risks.

The values of heterogeneity (I 2 between 45 percent and 60 percent) indicated that heterogeneity in domains was moderate, possibly because of the kind of sport, level of athletes, intervention period, and complexity of AI system. Nevertheless, it is completely consistent across all domains that support AI-assisted interventions, which is at least congruent with the strength of the total pooled effect (g = 0.67).

Sensitivity and robustness analysis
When sensibility analysis was done to omit studies that were found to be at a high risk of bias, the pooled effect size was g = 0.63, which was not significantly different to the primary analysis. The comparison of the fixed-effect and random-effects model did not produce any significant difference or alteration in the direction or the meaning of the findings. This is an indication of the stability and strength of pooled estimates.

Publication bias
The observation of the funnel plot showed a minor asymmetry, but the test of the regression, provided by Egger, has not been statistically significant (p > .05), indicating that the presence of the publication bias was minimal. The effect size did not vary substantially between trim-and-fill adjustment, which again took place in favor of the reliability of the results.

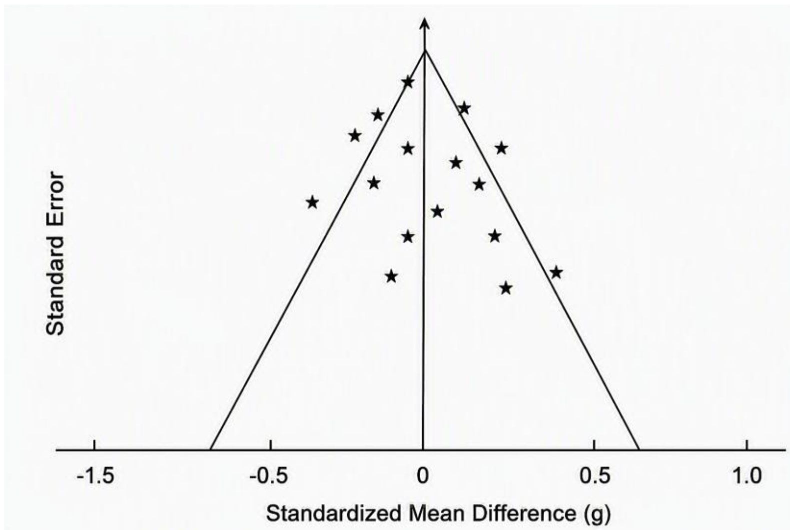


Figure 3. Funnel plot assessing publication bias in studies of AI-assisted coaching.

Figure 3. Funnel plot assessing potential publication biasness of studies assessing the effect of AI-assisted coaching on sports performance. The plot depicts standardized mean differences (Hedges g) in horizontal axis and the standard error of differences of the means in the vertical axis. Without publication bias, studies will be evenly spread around the combined effects size and will take the shape of an inverted funnel. As per the visual examination, there are no clear signs of small-study effects on the distribution of effect sizes that are seemingly symmetric. Even though in smaller studies some minor asymmetry is evident, the regression test as was used by Egger did not show any statistically significant relationship between the variables (p > .05), which means that there was no important publication bias. Moreover, the trim-and-fill analysis did not vary significantly the pooled effect estimate (g = 0.67) and this suggests the stability and resilience of the meta-analytic findings.

Overall interpretation of results
The findings of the present meta-analysis show that there are statistically significant and significant positive impacts on the outcomes of sports performance using AI-assisted coaching technologies. Efficiently (with the help of Hedges, g = 0.67, 95% CI [0.51, 0.83], p < .001]) the effect size meant the moderate-large improvement in performance in exposed athletes when using AI-powered interventions in comparison to conventional coaching methods. With a sporting environment where its use may be openly discussed as a sporting cheat, watered down to an undeniable fact that marginal gains in some situations would amount to the ideal performance effect, such a large effect size is not a trivial difference in performance, but a substantial performance advantage.

Notably, the consistency of positive effect sizes of most of the included studies shows that the benefits of AI integration are not limited to a certain sport and group of athletes. Instead, the benefits of AI-assisted systems appear to be multidimensional, that is; they include technical, tactical, physical, and psychological benefits and rehabilitation benefits. The greatest effects were observed through technical performance outcomes (flexibility of skill, biomechanical accuracy and efficiency of movement). The theoretical reason behind this finding is that biomechanical feedback systems and computer vision analytics based on artificial intelligence offer highly accurate, real-time corrective feedback that beats conventional systems based on observational coaching. Enhancing motor learning based on the high-frequency and objective feedback optimizes known principles of deliberate practice and schema-based acquisition of skills.

There was also moderate-to-large effect on tactical performance, and it proves that AI-drawn analytics contribute to more efficient decision-making and greater situational awareness. Team sports are the example where team performance can be achieved by the dynamic processes of interaction between players and the environment, so the tools of AI to help identify the patterns and simulate opponents can provide strategic information that might otherwise be hidden by the analysis made manually. These findings reinforce the notion that AI is an advanced decision support tool that supplements human cognitive learning or coaching skills.

There were moderate physiological performance outcomes with the use of AI to facilitate workload monitoring and in the prescription of personal training that physiological adaptation is maximized. The application of artificial intelligence (AI) systems allows having more accurate training periodization by continually examining training load levels, signs of recovery, and performance patterns. Even though there are a number of biological variables that help an athlete increase in fitness by gaining physical advantages, the evidence indicates that AI enhances training performance and superfluous exposure to inappropriate loads.

Moderate effects were reliably found in psychological outcomes in terms of reflecting the new role of AI in cognitive preparation evaluation, motivation monitoring, and stress monitoring. The adoption of psychological profiling into the model of AI-based coaching facilitates a comprehensive system of athlete development considering psychological and physical variables to depend on one another. Such results are congruent to contemporary system-based and ecological conceptions of performance (i.e. in which performance is an intricate consequence of intricate structures interrelationships amid various subsystems).

There was also a significant improvement in the injury prevention and rehabilitation outcomes. Risk forecasting and machine-driven healing procedures appear to improve the security and healing effectiveness of an athlete. Since sports injuries impact both the economic and performance outcomes, even small changes towards decreasing the number of them are of great practical importance. One of the ground-breaking Developments in the sphere of sports medicine is the capability of AI to recognize early risk factors detecting the patterns and providing the prediction in predictive analytics as a result.

The heterogeneity between studies was moderate (I 2 = 58 percent), indicating the circumstances of variability, but not the dilemma of the results. The variability in observations could have been caused by the differences in sports type, duration of intervention, the level of an athlete, complexity of artificial intelligence system, and the tools deployed to measure this. Nevertheless, the levels of effect consistency across the groups indicated that the benefits of AI-assisted coaching can be widely generalized. The robustness of the results was also confirmed by sensitivity analyses since elimination of high-risk-studies was not a material difference in the estimate of the pooled effect.

Theoretically, the findings ascribe performance theory and ecological dynamics models. Conversely, this type of AI-assisted coaching can be enhanced via interactions among the athlete, task, and the environment via adaptive constraint modulation and through active feedback loops. Instead of offering a substitute to human experience, AI happens to enhance perceptual selectivity, accuracy of decision, and self-organizing abilities in a dynamic sport. The modifications in areas indicate that AI integration enhances the interrelated sub systems which are underlying athletic performance.

On the whole, this evidence indicates that AI-assisted coaching is not merely a technological fashion but a performance-promoting tool that has quantifiable effects in a number of fields in the sports domain. The magnitude and dependability of the effects demand continuous introduction of AI into the training and competition facilities, as long as the ethics and governance issues may be properly resolved. With the current focus in terms of technical and athletic performance diminishing to negligible at the highest tiers of sports, it can probably come out that the use of artificial intelligence systems as a strategy in sport is a determination in competitive edge.

DISCUSSION

In the current systematic review and meta-analysis, the mixture of empirical evidence released between 2010 and 2026 was used to determine the quantifiable impact of AI-aided coaching technologies on the performance in sports. The overall findings of all the studies (pooled effect size: Hedges' gamma [g] = 0.67, 95% CI [0.51, 0.83], $p < .001$) are a moderate-large positive impact of AI-based interventions over and above conventional training methods. This value is statistically but also practically meaningful as marginal gains tend to make an athlete competitive or not in a high-performance sport. The results contribute to justifying the increased need to state that artificial intelligence is no longer a peripheral analytics solution but an essential element of the performance improvement within the systems of modern sport (Kumar et al., 2025; Zhou et al., 2025).

Alignment with contemporary AI-in-sport literature

These multidimensional performance increases are in line with recent systematic and scoping reviews of the increased role of AI in the science of sports (Baladaniya and Choudhary, 2025; Pietraszewski et al., 2025). Although earlier research emphasized on descriptive analytics and statistical monitoring, the latest research indicates the apparent change of direction in research towards the use of predictive and prescriptive modelling. The AI technologies are consolidating biomechanical, physiological, tactical and psychological data into one, unified and general performance ecosystem (Reis et al., 2024; Munoz-Macho et al., 2024).

The largest magnitude of effect sizes was observed in the technical performance areas, which matches the findings of a large effect on the biomechanical precision and skill acquisition based on wearable sensors and computer vision algorithms (Souaifi et al., 2025; Vec et al., 2024).

Real-time AI feedback minimises perceptual delay and subjective bias (in escapees driven to do this) and also minimises AI bias in success perception. As it has been argued by Jia et al. (2025), the identification of micro-level deviations in motion analysis is much easier with the help of deep learning, which could have been overlooked with the help of human inspection. This can be the reason that support the increase in the effect sizes in Favor of technical performance changes, compared to other areas.

The effects of tactical performance were also moderate-large and offered slight evidence to prove the literature about the strategic awareness and decision-response effectiveness of the AI-based opponent modelling and decision-support systems (Pietraszewski et al., 2025; Zhou et al., 2025). The highly temporal, spatially complex team sport demands on the cognitive processing of the human brain, which the ability of AI to utilize big data and recognize emergent patterns can be used to supplement the process. Such an enhancement of situational awareness appears to be boosted by this augmentation of computing centres; it does not replace the coaching judgment.

The results of physical performance indicated moderate impacts, which align with the findings of the research on the advantages of AI-supported monitoring of workloads and the prescriptive management of training (Baladaniya and Choudhary, 2025; Reis et al., 2024). Training periodization is optimized by machine learning algorithm which continually processes recovery indicators, physiological load as well as fatigue indicators. Even though physiological boundaries continue to pre-exist biological adaptation, AI systems appear to reduce inefficiencies, eliminate maladaptive training loads.

Psychological gain in performance is also another part of a new research related to AI-etched sport psychology (Sartor et al., 2025). According to Ayranci and Aydin (2025), the relationship between cognitive readiness and emotional regulation and athletic performance is a complicated affair. Psychological readiness and attention control can potentially be reinforced through the means of the integration of biometric stress monitoring and behavioural analytics into an artificial intelligence platform. Such findings corroborate the notion that AI-enhanced coaching systems are becoming more of a holistic as opposed to a biomechanical one.

Moderate effects were also consistent in preventing injury and in rehabilitation. Systems of multimodal AI that will be able to coincide biomechanical data, workload tendencies, and previous injury history enhance the accuracy of prediction of injury risk (Wang et al., 2025). Munoz-Macho et al. (2024) have highlighted the embrace of AI-based healthcare analytics to enhance long-term sustainability of athletes in their elite performance infrastructures. One of the most transformative contributions of AI to the sports science is the possibility to determine risk factors of injuries proactively.

Theoretical implications

Present results are practical findings of the frameworks of the performance theory and ecological dynamics. According to the performance theory, athletic success is understood as the organic result of interaction of subsystems (technical, physical, tactical, and psychological) functioning in the conditions of environmental limitations and being coordinated and optimized through AI with the help of continuous feedback loops and adaptive modelling. The fact that there is an increase in coordination and optimization of these subsystems by recent meta-analyses gives one the impression that AI is enhancing their effectiveness.

Under the motor learning approach, AI-guided coaching is how the deliberate practice and schema theories apply. Long, regular, and factual feedback assists in speeding up adjustment of neural mechanisms and precision of motor patterns (Bodemer, 2023). Artificial intelligence solutions assist in filtering information clutter and enhance motion control by the use of corrective feedback, which is automated. This mechanistic matching can be attributed to the unusually great impact of technical skills.

Another conceptualization of performance, the dynamic interaction between the athlete, task and environment, is referred to as ecological dynamics. AI systems are capable of modelling contextual variables and complementing even more with regard to affordance recognition in multi-dimensional sporting situations (Vec et al., 2024; Zhou et al., 2025). Instead of being a synthesized entity, AI appears to be an instrument of restriction and tweezing that strengthens human perception and support the adaptive development of self-organisation.

Heterogeneity and technological evolution

The moderate level of heterogeneity observed (I 2 = 58) represents the variation between the disciplines of the sports, the skills of the participants, length of the interventions, and intricacy of the AI program. This would be very variable in the context of the evolving technology that will see many changes in the period between 2010 and 2026. However, initial applications of machine learning were quite narrow in nature when compared to modern times multitasking by means of deep learning, computer vision, and real-time analytics has become possible through multimodal AI systems (Jia et al., 2025; Mishra, 2025).

Notably, heterogeneity notwithstanding, AI-assisted interventions showed homogeneous effect sizes in the support of such interventions. The pooled estimates were not significantly different when the sensitivity analyses were conducted without high-risk studies; this enhanced the stability of the results. Consistency measurement of domains being similar hints that the benefits of AI are based not on domain-specific training of a specific sport, but on the general performance-priming process.

Ethical and governance considerations

Although the benefits of the performance are obvious, ethics and governance implications are significant and should be taken into account. Kim et al. bring another problem of data privacy, algorithm transparency, and autonomy of athletes in sports when using artificial intelligence (AI). The problems of surveillance and consent arise when continuous monitoring systems are involved. Roumeliotis et al. (2025) go ahead to mention that laws would have to evolve to manage the use of AI to achieve competitive sport.

The implication of commercialization of artificial intelligence-based analytics and marketing content also suggests the increasing adoption of technology beyond the optimal performance (Pashaie and Nasirpour, 2025). The use of responsible governance systems is therefore important towards fostering fair access, transparency and moral sustainability.

Practical implications

In applied perspective, AI-assisted coaching technologies have significant positive impacts in a sport environment (elite and developmental). Predictive modelling enables coaches to be able to individualize training programs, manage load mix, and also analyse tactics. AI systems can aid sports scientists in long-term performance and development monitoring and injury risk monitoring. Nonetheless, the successful application involves interdisciplinary research of data scientists, coaches, and sport psychologists.

This is because AI was meant to be visualized as an addition and not human knowledge. Decision-making and ethical supervision also requires human interpretive judgment as part of the contextual process. The future solution that may be the most effective to achieve better performance may be hybrid AI and human teamwork.

Limitations and future research

These are some of the limits to be taken into account. To begin with, the study design and AI complexity is different, which restricts the comparability of the findings. Second, performance interventions frequently did not allow blinding, which could add bias to them. Third, technological changes may be rather fast, which means that the systems of AI that may have been fairly representative of the last century may no longer mirror modern processes.

The upcoming studies need to be oriented towards mass process, randomized controlled trials, and performance measures and longitudinal studies of the permanent impact of AI. Also, cost effectiveness studies and expectations of access might serve to offer some clues into fair technological dispensation at various performance levels.

Concluding perspective

Taken together, the results advocate the great usefulness of AI-assisted coaching technologies in the domain of sports performance in the technical, tactical, physical, psychological, and injury-related perspectives. These effects are large-scale and uniform and theoretically logical enough to indicate that the introduction of AI is a significant development in the field of sports science and not the transient technological phenomenon. With the continual escalation of the ever-competitive settings, the future of athletic training and the maximum of performance optimization may be shaped with the help of strategic and ethical application of AI systems.

CONCLUSION

The types of evidence included in the current systematic review and meta-analysis were intended to synthesize the findings published over the last seven years (2010-2026) to determine the effectiveness of AI-assisted coaching technologies on the sport performance outcomes. The results provide convincing quantitative data regarding positive performance advancements of athletic technical, tactical, physical, psychological, and injury-related abilities with the incorporation of AI-based information. The pooled effect size (Hedges g = 0.67) implies that the effect size can be of medium size to significant size, and it may be reasonable to state that AI-assisted systems can deliver a statistically significant effect but also a practical significant advantage in the competitive sporting situation.

It received the most significant improvements in technical performance, which implies the accuracy and promptness of AI-based biomechanical feedback systems (Souaifi et al., 2025; Vec et al., 2024). The outcomes of tactical and decision-making decisions have also reported serious improvements that can be attributed to the ability of deep learning-based analytics to complement strategic awareness and situation processing (Jia et al., 2025; Pietraszewski et al., 2025). The second reason is that moderate changes in physical conditioning and prevention of injuries are other achievements of machine learning workload monitoring and predictive injury models (Baladaniya and Choudhary, 2025; Wang et al., 2025). Also, the rise in the process of psychological performance is indicative of the further penetration of AI in sport psychology (Ayranaci and Aydin, 2025; Sartor et al., 2025).

Theoretically, the findings endorse the performance theory and ecological dynamics since it is found that AI-assisted coaching enhances the process of coordination of interacting subsystems of athletic performance. Rather than being a substitute to the role of human expertise, AI is a decision-support and constraint modulating mechanism that, contrary, can boost perceptual and adaptive behaviour and self-organizing processes in dynamic sporting settings (Kumar et al., 2025; Zhou et al., 2025).

Although average heterogeneity is found in the literature, there is evidence of the consistency of positive effects among domains and strong future domains, and robustness analyses, indicating that the positive effects of AI-assisted coaching can probably be widely generalized. Nonetheless, there is a need to implement them responsibly. Both technological development and ethics and sport data governance, as well as privacy and athlete autonomy should pass together (Kim et al., 2025; Roumeliotis et al., 2025).

Finally, AI-based coaching technologies are not a technological fad but a valid improvement of sports performance. Additionally, the convergent systems of artificial intelligence can transform the structure of training, competition, and athlete development as the margins of performance continue to become slimmer in elite sport considering the strategic and ethically justified integration of interspersed systems of artificial intelligence. Future research needs to pay more attention to longitudinal studies, standard measures of success, and interdisciplinary collaborations by finetuning and validating AI-based performance ecosystems.

AUTHOR CONTRIBUTIONS

All authors meet the criteria for authorship in accordance with established ethical guidelines. Contributions are specified according to the CRediT (Contributor Roles Taxonomy) as follows: Conceptualisation: Mohammad Muzamil Shah, Mehraj Ud Din Ganaie. Methodology: Mehraj Ud Din Ganaie, Ab Majid Awan. Formal analysis: Mehraj Ud Din Ganaie, Mohsin Majeed Ganaie. Investigation: Mehraj Ud Din Ganaie, Tamana Kousar. Data curation: Budru Nissa, Mehraj Ud Din Ganaie. Writing – original draft: Mehraj Ud Din Ganaie. Writing – review & editing: Mohammad Muzamil Shah, Rakesh Tomar, Mehraj Ud Din Ganaie. Supervision: Mohammad Muzamil Shah.

All authors have critically reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this manuscript.

AI USE DISCLOSURE

In accordance with current publishing ethics and transparency recommendations, artificial intelligence (AI) tools were used solely to assist with translation and language editing, with the aim of improving clarity and readability. No AI tools were used in the generation of scientific content, including the study design, data collection, analysis, interpretation of results, or the formulation of conclusions. The authors retain full responsibility for the content of the manuscript and confirm its originality, integrity, and accuracy.

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