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Talent Identification in Youth Sport: A Systematic Review of Multidimensional Predictors

Islam Mahmoud

Sports Training Department, Faculty of Sport Sciences, Mansoura University, Mansoura, Egypt
Email: mosaad_is@mans.edu.eg

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Abstract

Discovering athletic talent is one of the most complex predictive challenges in sports science. Unlike assessing adult performance, identifying young talent requires predicting their long-term athletic potential under conditions of biological variability, developmental instability, and environmental inconsistency. Consequently, early detection processes often rely on incomplete performance indicators and are subject to structural biases such as the effects of biological maturation and relative age. This systematic review with an umbrella component aimed to synthesize contemporary primary and secondary evidence (2020-2026) on biological, psychological, and computational indicators used in athletic talent identification systems. In accordance with the PRISMA 2020 guidelines, database searches across major publishing platforms yielded 703 records, of which 32 records met the final inclusion criteria, comprising primary empirical studies, complementary conceptual evidence, and two systematic reviews forming the umbrella component. The results indicate that the selection of athletes in the early stages is strongly influenced by biological maturation and relative age effects, which can distort developmental trajectories and affect the accuracy of talent identification. Recent research increasingly supports multidimensional assessment models that integrate physical, technical, tactical, and cognitive variables, improving predictive accuracy compared to single-domain approaches. In addition, machine learning approaches are emerging as promising analytical tools capable of modeling the complex interactions between talent indicators. However, limitations remain regarding external validation, interpretability, and potential bias in datasets. Overall, the available evidence supports further investigation of hybrid frameworks combining objective assessment, structured expert judgment, and computational modelling. Future research should prioritize longitudinal validation across developmental stages, assessment strategies adapted to maturity, and transparent governance

of algorithmic decision-making processes.

Keywords

Talent Identification, Youth Sport, Athlete Development, Relative Age Effect, Biological Maturation, Machine Learning

1. Introduction

Talent identification is one of the most challenging predictive tasks in sports science and athlete development research. While the evaluation of elite adult athletes focuses on measurable performance outcomes, talent identification seeks to predict future athletic potential during early developmental stages, when performance indicators remain volatile and highly sensitive to biological and environmental influences (Vaeyens et al., 2008). Consequently, early selection decisions are often made under conditions of uncertainty, where short-term performance advantages may not accurately reflect long-term athletic potential.

Historically, traditional talent identification systems have relied on isolated anthropometric or physiological measurements, such as height, speed, strength, and endurance. However, contemporary theoretical perspectives increasingly reject reductionist models of talent. Instead, talent is now viewed as a multidimensional and dynamic construct, arising from complex interactions between biological predispositions, psychological characteristics, the acquisition of technical skills, and environmental opportunities (Baker & Wattie, 2018; Johnston et al., 2018). This systemic perspective challenges the assumption that early physical performance alone is sufficient to predict elite success.

Among the most prominent and consistently reported limitations of youth talent identification systems are the effects of biological maturation and relative age effects (RAE). Relative age effects commonly involve the overrepresentation of athletes born earlier in the selection year within youth development programs (Cobley et al., 2009). Early-born athletes often exhibit temporary advantages in height, strength, and neuromuscular development, increasing their likelihood of selection during adolescence (Kelly et al., 2021). While these advantages may facilitate short-term performance, longitudinal studies indicate that biological maturation alone cannot reliably predict long-term elite achievement (Romann & Fuchslocher, 2020).

In response to these limitations, research over the past decade has increasingly focused on multidimensional assessment frameworks. These approaches integrate diagnoses of physical performance with technical, tactical, cognitive, and psychological indicators of athlete development. For example, large-scale national studies in youth football show that combining coach assessments with objective performance tests significantly improves prediction accuracy compared to single-domain screening models (Höner et al., 2021). Similarly, systematic reviews across

various sports highlight the importance of integrating diverse performance domains to understand the complex nature of athletic experience (Sarmento et al., 2018).

In addition to these methodological advancements, developments in artificial intelligence and machine learning have opened new possibilities for analyzing high-dimensional talent identification datasets. Machine learning algorithms are capable of modeling nonlinear interactions among a large number of variables, potentially improving prediction accuracy in complex developmental systems (Siener et al., 2021). Recent studies applying random forest models and neural networks have shown promising results in identifying athletes' developmental trajectories across large cohorts (Liu et al., 2024). However, the application of machine learning in talent identification also raises important concerns regarding algorithmic bias, data quality, and model interpretability (Tang et al., 2026).

Despite increasing methodological advancements, numerous challenges persist in the field of sports talent identification. These challenges include inconsistencies in operational definitions of talent and exceptional performance, limited longitudinal validation of predictive models, and inadequate integration of psychological and environmental factors within quantitative frameworks (Zhao et al., 2024). Consequently, contemporary research increasingly advocates for hybrid approaches that combine objective diagnosis, expert interpretation, and computational analysis within transparent and ethically sound systems.

Therefore, this systematic review aimed to synthesize the empirical evidence published between 2020 and 2026 concerning predictors and methodologies used in sports talent identification research. Specifically, the review sought to:

1. Examine biological, psychological, and performance-based predictors used in youth talent identification systems.

2. Evaluate the reliability of subjective and objective assessment methodologies.

3. Assess the growing role of machine learning and artificial intelligence in talent prediction.

4. Identify methodological limitations and suggest directions for future research.

By integrating multidisciplinary evidence across sports, this review aims to provide a comprehensive overview of the current state of talent identification research and contribute to the development of more reliable, equitable, and scientifically based athlete selection systems.

2. Methods

2.1. Study Design

The database search was conducted in March 2026. This study was designed as a systematic review with an umbrella component and followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Page et al., 2021) guidelines.

2.2. Eligibility Criteria

Records were eligible if they addressed talent identification, selection, or development among youth or emerging athletes; were published in English between January 2020 and March 2026; and provided evidence directly relevant to the predefined review questions. Primary empirical evidence included quantitative and qualitative studies, cross-sectional and longitudinal studies, observational research, mixed-methods studies, and computational studies or predictive models.

Systematic reviews directly addressing the review questions were eligible for the umbrella component. Publications of conceptual relevance were retained if they directly addressed methodological and structural challenges in contemporary sports talent identification and development and contributed to the interpretation of empirical evidence.

Records focusing exclusively on adult performance enhancement, non-sporting talent domains, conference abstracts, or editorials and commentaries not substantively linked to the pre-defined review questions as well as publications that did not address talent identification, selection, or development were excluded. The final synthesis included 32 eligible records comprising primary empirical evidence, supplementary conceptual evidence, and two systematic reviews (Han et al., 2023; Tang et al., 2026) that constituted the core component. Evidence types were distinguished throughout the synthesis process, and primary studies already included within the systematic reviews were not counted as independent, additional support at the study level.

2.3. Screening and Eligibility Assessment

The study selection process followed the PRISMA framework. The initial search yielded 703 records. After removal of 186 duplicates, 517 records remained for title and abstract screening. During screening, 438 records were excluded. A total of 79 full-text reports were assessed for eligibility, of which 47 were excluded because they did not satisfy the predefined eligibility criteria. Ultimately, consequently, 32 eligible records were retained in the final synthesis. Title and abstract screening and full-text eligibility assessment were conducted by the principal investigator using the prespecified eligibility criteria. Because screening was undertaken by a single reviewer, independent duplicate screening was not performed and no reviewer-disagreement resolution procedure was applicable.

2.4. Information Sources and Search Strategy

A systematic literature search was conducted across PubMed, Scopus, Web of Science Core Collection, SPORTDiscus, and IEEE Xplore. The strategy was adapted to the syntax and searchable fields of each source while retaining four principal concept groups: talent identification/development, sport/athletes, youth/developmental populations, and assessment/prediction-related factors. Boolean operators, phrase searching, truncation where supported, and source-specific field searching were used.

The searches covered publications from 1 January 2020 through March 2026. The electronic searches yielded 674 records: PubMed (n = 142), Scopus (n = 198), Web of Science Core Collection (n = 164), SPORTDiscus (n = 96), and IEEE Xplore (n = 74). An additional 29 records were identified through reference-list searching, producing 703 records before duplicate removal. Complete source-specific strategies are reported in Table 1.

Table 1. Electronic information sources and complete search strategy.

Source/interface	Fields	Search strategy	Records
PubMed/NLM	Title/Abstract	(("talent identification" [Title/Abstract] OR "talent development" [Title/Abstract] OR "talent selection" [Title/Abstract] OR "talent detection" [Title/Abstract] OR "athlete selection" [Title/Abstract]) AND (sport* [Title/Abstract] OR athlete* [Title/Abstract]) AND (youth [Title/Abstract] OR adolescent* [Title/Abstract] OR junior [Title/Abstract] OR "young athlete*" [Title/Abstract]) AND (predict* [Title/Abstract] OR assess* [Title/Abstract] OR performance [Title/Abstract] OR "biological maturation" [Title/Abstract] OR "relative age" [Title/Abstract] OR psychological [Title/Abstract] OR multidimensional [Title/Abstract] OR "machine learning" [Title/Abstract] OR "artificial intelligence" [Title/Abstract]))	142
Scopus/Elsevier	TITLE-ABS-KEY	TITLE-ABS-KEY (("talent identification" OR "talent development" OR "talent selection" OR "talent detection" OR "athlete selection") AND (sport* OR athlete*) AND (youth OR adolescent* OR junior OR "young athlete*") AND (predict* OR assess* OR performance OR "biological maturation" OR "relative age" OR psychological OR multidimensional OR "machine learning" OR "artificial intelligence"))	198
Web of Science Core Collection/ Clarivate	Topic (TS)	TS = (("talent identification" OR "talent development" OR "talent selection" OR "talent detection" OR "athlete selection") AND (sport* OR athlete*) AND (youth OR adolescent* OR junior OR "young athlete*") AND (predict* OR assess* OR performance OR "biological maturation" OR "relative age" OR psychological OR multidimensional OR "machine learning" OR "artificial intelligence"))	164
SPORTDiscus/ EBSCOhost	Title/Abstract/Subject Terms	(("talent identification" OR "talent development" OR "talent selection" OR "talent detection" OR "athlete selection") AND (sport* OR athlete*) AND (youth OR adolescent* OR junior OR "young athlete*") AND (predict* OR assess* OR performance OR "biological maturation" OR "relative age" OR psychological OR multidimensional OR "machine learning" OR "artificial intelligence"))	96
IEEE Xplore	Metadata	(("talent identification" OR "talent development" OR "talent selection" OR "athlete selection") AND (sport OR athlete) AND (youth OR adolescent OR junior OR "young athlete") AND (prediction OR assessment OR performance OR "machine learning" OR "artificial intelligence"))	74
Electronic sources total	—	—	674
Reference-list searching	References	Backward citation searching	29
Total identified	—	—	703

2.5. Data Extraction

Data extraction was conducted by the principal investigator using a standardized

extraction framework. The following information was recorded:

- Author(s) and year of publication;
- Sport and sample characteristics;
- Study design;
- Predictor domains examined (e.g., biological, technical, psychological);
- Analytical or modeling methods;
- Outcome definitions;
- Key findings;
- Reported limitations.

2.6. Data Synthesis

Due to variation across sports, predictor variables, and research designs, a meta-analysis was not considered appropriate.

Instead, findings were organized into five thematic evidence domains:

1. Conceptual and structural foundations of talent identification;
2. Biological maturation and relative age effects;
3. Multidimensional performance profiling;
4. Reliability of subjective versus objective assessments;
5. Machine learning and computational modeling.

This thematic approach allowed for the identification of consistent patterns and methodological trends across the included studies.

2.7. Methodological Quality and Risk of Bias Assessment

Methodological limitations were assessed using a design-specific framework based on established critical appraisal tools. Quantitative observational studies were evaluated against the relevant Joanna Briggs Institute (JBI) domains; qualitative and mixed-methods studies were appraised using qualitative design principles and the appropriate MMAT criteria, respectively; and prediction or machine learning studies were assessed against PROBAST domains covering participants, predictors, outcomes, analysis, validation, and application. The two systematic reviews included in the overarching component were appraised separately against AMSTAR 2 domains. Given the methodological diversity of the included evidence, appraisal results were not converted into a standardized numerical quality score. Conceptual evidence was not subjected to an empirical risk-of-bias assessment. Table S1 summarizes study-level methodological strengths and issues. The assessment was conducted by the lead researcher and was not independently replicated.

3. Results

3.1. Study Selection

Consequently, 32 studies were included in the final synthesis. The study selection process is summarized in Figure 1.

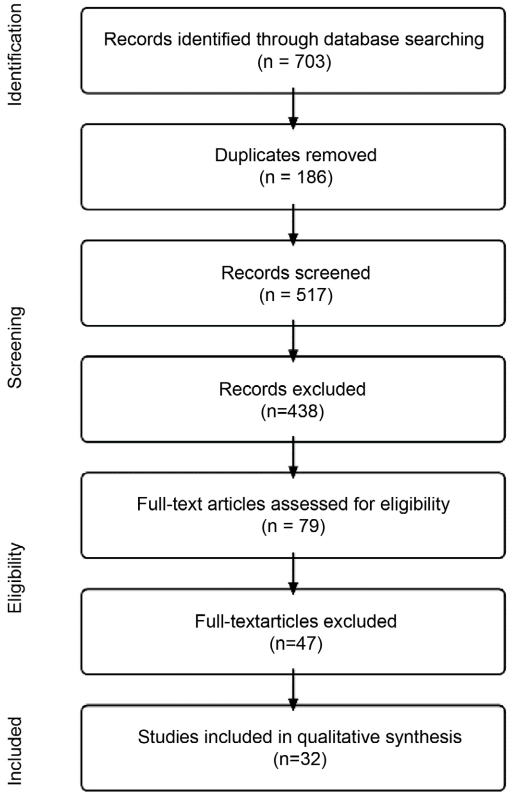


Figure 1. PRISMA 2020 flow diagram of the study selection process.

3.2. Study Characteristics

The 32 included records, published between 2020 and 2026, represented a wide range of sporting contexts and methodological approaches. Soccer accounted for the largest proportion, with 18 records. The remaining records represented volleyball (3), rugby union (2), multi-sport analyses (3), basketball (1), swimming (1), tennis (1), triathlon (1), track and field (1), and Australian football (1). Together, these categories account for all 32 included records.

The evidence base included cross-sectional and observational investigations, prospective and retrospective longitudinal studies, qualitative and mixed-methods research, prediction and machine-learning studies, complementary conceptual evidence, and two systematic reviews. Because prediction modelling and machine learning may be embedded within longitudinal or observational designs, these methodological categories were not treated as mutually exclusive study-design classifications.

Sample sizes varied considerably, ranging from small qualitative studies involving expert coaches or scouts (8 - 25 participants) to large-scale national studies with more than 10,000 young athletes.

In the included studies, a wide range of predictive domains were examined, including anthropometric characteristics, measures of physiological performance, technical and tactical skills, psychological traits, and environmental influences.

3.3. Methodological Quality and Risk of Bias

Methodological quality varied across the included records, reflecting heterogeneity in study design, population, outcome definition, and analytical approach (**Table S1**). Frequent concerns among observational and cross-sectional studies included context-specific sampling, potential residual confounding, and reliance on contemporaneous selection or squad membership as a proxy for longer-term talent outcomes.

Prospective and longitudinal investigations generally provided stronger temporal evidence. Large-scale studies such as Höner et al. (2021), Leyhr et al. (2025), and Saward et al. (2020) linked earlier athlete characteristics with subsequent developmental or selection outcomes and were therefore given greater interpretive weight for prognostic questions. Prediction and machine-learning studies introduced additional concerns relating to model complexity, potential optimism, external validation, interpretability, and transportability. The two systematic reviews (Han et al., 2023; Tang et al., 2026) were interpreted in relation to heterogeneity and methodological limitations in their underlying evidence.

3.4. Biological Maturation and Relative Age Effects

Biological maturation and relative age have emerged as recurring factors associated with selection and representation processes within youth athlete development pathways. Studies across sports such as soccer, rugby union, and volleyball have highlighted disparities linked to relative age and/or maturation status in the selection and development of young athletes (Kelly et al., 2021; King et al., 2024; Morganti et al., 2025; Rubajczyk & Rokita, 2020; Saward et al., 2020).

Athletes born earlier in the year and/or those who are more biologically mature may exhibit temporary advantages in anthropometric measurements and physical performance during adolescence. Such differences can influence selection decisions when the primary focus is on current physical performance levels (Kelly et al., 2021; King et al., 2024; Rubajczyk & Rokita, 2020). Evidence from longitudinal studies indicates that growth and development trajectories can shift during adolescence, and that early physical advantages should not be viewed as definitive indicators of long-term elite potential (Saward et al., 2020; Höner et al., 2021).

3.5. Multidimensional Performance Profiling

A significant methodological trend is the notable increase in the use of multidimensional assessment methods; studies have integrated a range of indicators including anthropometric, physiological, skill-based, tactical, and cognitive factors, alongside other performance metrics rather than relying exclusively on isolated physical measures (Dimundo et al., 2021; Höner et al., 2021; King et al., 2024; Leyhr et al., 2025; Sgrò et al., 2024; Barraclough, 2025b).

Evidence indicates that multidimensional assessment yields information that extends beyond discrete performance indicators, although the contribution of each domain varies depending on the sport, the developmental stage, and the out-

comes of the selection process (Höner et al., 2021; King et al., 2024; Leyhr et al., 2025).

3.6. Reliability of Subjective and Objective Assessment Methods

Many studies included in this research have examined objective performance tests, expert subjective assessments, or the relationship between these two approaches (Bergkamp et al., 2022; Dugdale et al., 2020; Höner et al., 2021; Höner et al., 2025). Objective assessments provide standardized measurements of selected physical and motor performance characteristics, whereas coaches and talent scouts can incorporate contextual information related to performance within sport-specific environments.

Evidence comparing these approaches suggests that objective and subjective assessments capture at least partially different aspects of an athlete's potential (Höner et al., 2021; Höner et al., 2025). Consequently, the available evidence supports exploring their complementary use within structured, hybrid assessment frameworks, rather than assuming the inherent superiority of one approach over the other.

3.7. Machine Learning and Computational Modeling

There is growing interest in exploring computational methods and machine learning techniques to analyze multidimensional data related to talent identification (Siener et al., 2021; Liu et al., 2024; Tang et al., 2026). In the realm of junior tennis, the predictive validity of statistical methods based on motor abilities has been examined (Siener et al., 2021), while "random forest" models have been applied to anthropometric and physiological characteristics to predict talent in swimming (Liu et al., 2024).

However, methodological evidence indicates persistent challenges particularly regarding external validation, inconsistent outcome definitions, model interpretability, and the generalizability of findings across different sports and populations (Tang et al., 2026). Therefore, machine learning should be viewed as an advanced approach to support decision-making, rather than an established substitute for traditional assessment methods or expert judgment.

3.8. Synthesis of Evidence across Domains

Available evidence indicates that talent identification is typically studied as a multidimensional process encompassing a combination of physical, technical, tactical, cognitive, psychological, and contextual characteristics (Dimundo et al., 2021; Höner et al., 2021; Leyhr et al., 2025; Sgrò et al., 2024). Furthermore, both biological maturation and relative age have been linked to patterns of youth selection and representation (Kelly et al., 2021; King et al., 2024; Morganti et al., 2025; Rubajczyk & Rokita, 2020). Objective tests and expert assessments appear to provide complementary information, rather than demonstrating the consistent superiority of one method over the other (Bergkamp et al., 2022; Dugdale et al., 2020;

Höner et al., 2021; Höner et al., 2025). While computational methods have shown promising potential, they require further robust external validation (Siener et al., 2021; Liu et al., 2024; Tang et al., 2026).

4. Discussion

This systematic review synthesized contemporary empirical evidence on predictors and methodologies used in youth sport talent identification systems. Five key findings emerged from the analysis: (1) The persistent influence of biological maturation and relative age effects; (2) The growing adoption of multidimensional performance assessment models; (3) The complementary roles of objective testing and expert evaluation; (4) The increasing use of machine learning techniques; (5) The structural limitations of current talent identification frameworks.

4.1. Talent Identification as a Multidimensional Developmental Process

A key finding in the reviewed literature was the growing shift from reductionist talent identification models to multidimensional assessment frameworks. Historically, talent identification systems have relied heavily on isolated anthropometric and physiological indicators, such as height, speed, and strength. Although these variables are important in assessing short-term athletic performance, the evidence compiled in this review demonstrates their limited ability to predict long-term elite success.

This finding supports contemporary theoretical perspectives that portray talent as a dynamic developmental construct arising from complex interactions between biological, psychological, technical, and environmental factors (Baker & Wattie, 2018; Johnston et al., 2018). Multidimensional profiling approaches, which combine physical testing with assessments of technical skills, tactical perception, and psychological traits, have consistently been associated with improved predictive power across various athletic contexts.

The adoption of multidimensional assessment frameworks reflects a broader shift in athlete development research toward systems-based performance development models, which highlight an athlete's potential through the interplay between individual abilities and environmental opportunities. Consequently, effective talent identification systems must move beyond isolated performance indicators and instead incorporate integrated assessment models capable of accommodating the complexity of athletes' developmental pathways.

4.2. Biological Maturation and Structural Bias in Youth Selection

Another key finding of this review is the continued influence of biological maturation and relative age on youth athletic talent identification systems. In multiple sporting contexts, athletes born earlier in the selection year were disproportionately represented in elite development programs. These findings are consistent with previous research showing that early-born athletes often possess temporary

developmental advantages during adolescence due to differences in the timing of biological maturation (Cobley et al., 2009; Kelly et al., 2021).

These advantages are typically manifested through increased body size, strength, and neuromuscular development, which may improve short-term performance outcomes in youth competitions. However, longitudinal evidence suggests that these early physical advantages do not reliably predict outstanding long-term performance. As maturation differences gradually diminish during late adolescence, athletes who matured later and were previously overlooked may achieve similar or even better performance levels.

These findings suggest that relative age effects represent structural biases inherent in youth sports development systems, rather than accurate indicators of athletic potential. Consequently, many researchers have advocated for the implementation of maturity-adjusted assessment strategies, such as biological age estimation, growth trajectory monitoring, and age grouping policies designed to minimize selection bias.

Addressing these structural biases is crucial for improving the accuracy and fairness of talent identification systems, particularly in sports where early selection decisions can significantly impact access to coaching, training resources, and competitive opportunities.

4.3. The Complementary Roles of Objective Diagnosis and Expert Assessment

The reviewed studies also highlight the complementary roles of objective diagnostic tests and expert assessment in talent identification processes. Objective assessments, including standardized motor skills tests and physiological performance measurements, provide reliable and quantifiable indicators of athletes' abilities. However, these measures are often limited in their ability to capture complex performance characteristics, such as tactical awareness, cognitive decision-making, and the ability to adapt within dynamic competitive environments.

In contrast, expert assessments, conducted by experienced coaches and scouts, can provide valuable contextual insights into athletes' performance within specific game contexts. However, subjective assessments can be influenced by cognitive biases, inferential methods, and inconsistencies in assessment criteria. The evidence synthesized in this review supports the complementary integration of objective assessment and structured expert judgment through hybrid assessment models. This hybrid approach reflects the understanding that talent identification is not simply a measurement problem, but a decision-making process that requires integrating quantitative data with structured expert judgment.

4.4. Emerging Applications of Machine Learning in Talent Identification

Recent advances in artificial intelligence and machine learning have opened new possibilities for analyzing complex talent identification datasets. Machine learning

algorithms are particularly well-suited to modeling nonlinear relationships between multiple, interacting performance variables, making them valuable tools for analyzing multidimensional athlete development data.

Several studies included in this review have applied machine learning models, such as neural networks and random forest algorithms, to athlete datasets containing a large number of performance indicators. These models have demonstrated promising capabilities in identifying patterns associated with athlete development and performance outcomes.

However, despite their analytical advantages, the application of machine learning in talent identification is still in its early stages. Many studies have focused on predicting short-term performance outcomes rather than long-term elite success, and few models have undergone external validation across diverse athlete populations.

Furthermore, machine learning approaches raise significant ethical and methodological challenges, including potential algorithmic bias, limitations in interpreting complex models, and the risk of reinforcing existing structural inequalities in athlete selection systems.

For these reasons, current evidence suggests that machine learning should be viewed as a decision support tool, not a replacement for human expertise in talent identification processes.

4.5. Towards Integrated Hybrid Talent Identification Systems

Taken together, the findings of this review support further development and evaluation of integrated hybrid systems that combine multidimensional athlete profiling, expert assessment, and advanced computational analysis.

These systems will incorporate several key principles:

- Multidimensional assessment of athletes' abilities;
- Maturity-adapted assessment strategies;
- Longitudinal monitoring of athletes' developmental trajectories;
- Integration of expert opinions and objective diagnoses;
- Transparent and ethically sound computer modeling.

Implementing these principles will enable talent identification programs to better account for the complexity and uncertainty inherent in athlete development, while minimizing the structural biases that currently influence youth selection processes.

4.6. Implications for Talent Development Systems

The findings of this review point to several important implications for practitioners, sports organizations, and policymakers responsible for athlete development systems. First, early selection processes should be approached with caution, particularly in sports where biological maturation differences significantly impact youth performance. Talent development pathways may benefit from delaying specialization and providing broader opportunities for athletes to participate, allow-

ing more time for developmental differences to stabilize.

Second, talent identification systems should prioritize longitudinal monitoring of athletes rather than evaluation at a single point in time, enabling coaches and practitioners to track developmental trajectories over time.

Finally, as machine learning and data analytics become increasingly integrated into sports science practices, governing bodies should establish clear ethical guidelines and transparent criteria for algorithmic decision-making within athlete selection systems.

4.7. Strengths of the Review

This review has several important strengths. First, it focuses on integrating recent empirical evidence from various sports and methodologies, providing a comprehensive overview of contemporary talent identification research. Second, the study integrates biological, psychological, and computational perspectives, enabling a multidimensional understanding of athlete development. Finally, the application of the PRISMA framework enhances the transparency and methodological rigor of the review process.

5. Review Limitations

Several limitations should be noted. First, the selection process was restricted to English-language publications, which may have introduced language bias. Second, significant heterogeneity regarding sports, participant ages, assessment methods, definitions of predictor variables, and outcome measures precluded a meaningful quantitative synthesis of the entire body of evidence. Third, several studies relied on outcomes related to selection or short- to medium-term developmental stages, rather than long-term elite performance among professional athletes. Fourth, football accounted for 18 of the 32 records included in the study, potentially limiting the generalizability of the findings to other sports. Fifth, machine learning applications remain methodologically diverse and are rapidly evolving, particularly regarding external validation and interpretability.

Furthermore, the screening of titles and abstracts, assessment of full-text eligibility, data extraction, and methodological assessment were conducted by a single reviewer rather than through independent, dual review. Despite the use of predefined eligibility criteria, a standardized extraction framework, and assessment procedures appropriate to the study design, the absence of independent, dual review may have increased the likelihood of errors in selection, extraction, or assessment.

6. Future Research Directions

Future research should prioritize prospective longitudinal designs that track athletes across multiple developmental stages—and, whenever possible, up to the professional performance level. Such designs would provide stronger evidence regarding whether characteristics associated with youth selection also predict long-

term athletic outcomes.

Future studies should also broaden the scope of multidimensional assessment by integrating psychological, cognitive, technical, tactical, biological, and environmental characteristics into clearly defined developmental models. Particular attention should be paid to maturity-sensitive assessment and the interplay between relative age, biological maturation, training exposure, and selection opportunities.

Research in prediction and machine learning requires a greater focus on developing transparent models, properly handling missing data and class imbalances, ensuring calibration and discrimination, and validating models on completely independent samples. External validation across different sports, countries, genders, and developmental systems is crucial before integrating computational models into high-stakes selection decisions.

Finally, future research should examine how to proactively combine objective measurements with structured expert judgments without reinforcing existing selection biases. Furthermore, increased methodological standardization regarding outcome definitions and reporting would improve comparability and evidence synthesis across talent identification studies.

7. Practical Implications

The findings of this review have numerous practical implications for coaches, sports organizations, and policymakers involved in athlete development systems.

First, talent identification programs should move beyond traditional, single-domain assessment models and adopt multidimensional frameworks that include physical, technical, tactical, cognitive, and psychological indicators of athletes' potential.

Second, professionals should exercise caution when making early selection decisions in youth sports. Due to the influence of biological maturation and relative age, early performance should not be interpreted as a definitive indicator of long-term athletic potential. Implementing maturation-sensitive assessment strategies can help reduce selection bias and promote fairness in development pathways.

Third, talent identification processes should focus on longitudinal monitoring of athletes rather than single-stage assessments. Continuous evaluation across developmental stages can provide a more nuanced understanding of athletes' progress and reduce the risk of prematurely excluding late-developing athletes.

Fourth, emerging technologies, such as machine learning and advanced performance analytics, offer valuable opportunities to support decision-making within talent identification systems. However, these tools should be carefully integrated and used as complementary resources alongside expert assessment, rather than being considered fully automated selection mechanisms.

8. Conclusion

Talent identification remains one of the most complex and challenging predictive tasks in sports science. The evidence compiled in this systematic review demon-

strates that athlete development is influenced by a wide range of interacting biological, psychological, technical, and environmental factors, making early predictions of outstanding performance inherently uncertain.

The findings suggest that traditional talent identification models, which rely solely on indicators of physical performance, are insufficient to accurately predict long-term athletic success. Instead, contemporary research increasingly supports multidimensional and hybrid approaches that integrate objective diagnosis, expert assessment, and computational analysis.

At the same time, structural biases associated with biological maturation and the effects of relative age continue to influence the selection processes of young athletes, highlighting the need for assessment frameworks adapted to maturation and more flexible developmental pathways.

Looking ahead, the ongoing integration of longitudinal athlete monitoring, multidimensional analysis, and advanced data analytics offers promising opportunities to improve the reliability and fairness of talent identification systems. By adopting scientific and ethically responsible approaches, sports organizations can better support the identification and development of future elite athletes.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Appendix. Supplementary Table

Table S1. Study-level methodological quality and risk-of-bias appraisal.

Study	Evidence/design	Appraisal approach	Principal strengths	Principal concerns	Overall methodological
Andrew et al. (2025)	Observational, female youth soccer	JBI observational	Defined national youth pathway	Context-specific; residual confounding	Some concerns
Barraclough et al. (2024)	Observational/ multidimensional soccer	JBI observational	Applied multidimensional assessment	Context-specific; long-term validity limited	Some concerns
Barraclough et al. (2025a)	Predictive classification, soccer	JBI + prediction domains	Integrates objective/ subjective information	Academy-specific; external validation concerns	Some concerns
Beldman et al. (2025, 2026)	Qualitative, volleyball coaches	JBI qualitative	Sport-specific expert knowledge	Subjective evidence; transferability	Some concerns
Bergkamp et al. (2022)	Cross-sectional survey; 125 scouts	JBI cross-sectional	Specialist scout sample	Self-report; no prospective verification	Some concerns
Cuba-Dorado et al. (2020)	Longitudinal; 247 triathletes	JBI cohort	Longitudinal competition outcomes	Sport-specific; limited transportability	Some concerns
Datson et al. (2020)	Retrospective predictive; 228 players	JBI + prediction domains	Objective tests; later outcome	Retrospective; selected sample	Some concerns
Dimundo et al. (2021)	Cross-sectional rugby; n=74	JBI analytical cross-sectional	Multidisciplinary measures	Single academy; selection ≠ long-term outcome	Some concerns
Doncaster et al. (2020)	Developmental/ contextual soccer	Design-appropriate	Contextual developmental	Limited causal inference	Some concerns
Dugdale et al. (2020)	Case comparison; 80 players + 12 coaches	JBI cross-sectional	Objective-subjective comparison	Single setting; small coach sample	Some concerns
Ford et al. (2020)	International survey; 29 clubs	JBI cross-sectional	International practice evidence	Self-report/response bias	Some concerns
Fortin-Guichard et al. (2022)	Longitudinal; 110 players	JBI cohort	Predictors precede academy selection	Single programme; proximal outcome	Some concerns
Han et al. (2023)	Systematic review/meta-analysis	AMSTAR 2 domains	PRISMA; multiple databases; meta-analysis	Heterogeneity; primary-study limitations	Moderate confidence/some concerns
Hohmann et al. (2021)	Prospective/ prognostic soccer	PROBAST-oriented	Prospective prognostic design	Transportability; construct coverage	Some concerns
Höner et al. (2021)	Prospective nationwide; n = 13,869	JBI cohort + PROBAST	Very large prospective sample	Programme-specific outcomes	Lower concern
Höner et al. (2025)	Predictive validity, soccer	PROBAST-oriented	Objective/subjective comparison	External validation/ generalizability	Some concerns
Kelly et al. (2021)	Observational pathway/RAE, rugby	JBI observational	Multiple pathway levels	Contextual/pathway confounding	Some concerns
King et al. (2024)	National selection; n = 90	JBI analytical cross-sectional	Technical/physical/ maturity data	Contemporaneous selection outcome	Some concerns

Continued

Larkin et al. (2020)	Qualitative; 12 recruiters	JBI qualitative	Experienced recruiters	Small specialist sample	Some concerns
Leyhr et al. (2025)	Prospective cohort; n = 264	JBI cohort + PROBAST	Prospective multidimensional later	National-programme context	Lower concern
Liu et al. (2024)	ML; 5444 baseline/4969 follow-up	PROBAST	Large cohort; 3-year follow-up	External validation/ interpretability	Some concerns
McCalman et al. (2025)	Mixed methods, soccer coaches	MMAT	Applied mixed-methods evidence	Specialist sample; transferability	Some concerns
McEwan et al. (2026)	Pan-European survey	JBI cross-sectional	Multi-country perspective	Self-report; non-longitudinal outcomes	Some concerns
Morganti et al. (2025)	Observational RAE, soccer	JBI observational	Broad contextual scope	Ecological associations; confounding	Some concerns
Romann & Fuchslocher (2020)	Developmental/TID evidence	Design-appropriate	Biological/relative-age focus	Context/design limitations	Some concerns
Rubajczyk & Rokita (2020)	Cross-sectional volleyball	JBI analytical cross-sectional	Federation-organized TID setting	Maturation/age confounding	Some concerns
Saward et al. (2020)	Longitudinal; n = 2875	JBI cohort	Large longitudinal professional outcome	Selection/survivorship influences	Lower concern
Severin et al. (2025)	Retrospective; n = 1311	JBI observational	Large standardized dataset	Squad discrimination ≠ future success	Some concerns
Sgrò et al. (2024)	Multidimensional volleyball; n = 55	JBI analytical cross-sectional	Multiple performance domains	Small sample; generalizability	Some concerns
Siener et al. (2021)	Long-term prediction; n = 174	PROBAST	Compares prediction approaches	Moderate sample; external validation	Some concerns
Tang et al. (2026)	Systematic review of ML	AMSTAR 2 domains	Validation/ interpretability focus	Heterogeneous primary ML evidence	Moderate confidence/some concerns
Till & Baker (2020)	Conceptual/ methodological	Not applicable	Methodological challenges/solutions	No empirical effect estimate	N/A—conceptual evidence

Note. Because the included evidence comprised heterogeneous quantitative, qualitative, mixed-methods, prediction-modelling, systematic-review, and conceptual records, no common numerical quality score was calculated. The table summarizes design-specific methodological strengths and limitations informed by established appraisal frameworks. Judgments should therefore be interpreted within study design rather than compared directly across different appraisal tools. Conventional empirical risk-of-bias assessment was not applicable to conceptual evidence.