# KhelQuest: AI-Powered Platform for Democratizing Sports

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**ABSTRACT**

Access to structured sports training and talent identification opportunities remains limited for many athletes due to geographical, economic, and infrastructural barriers. This paper presents KhelQuest, an Artificial Intelligence (AI)-powered mobile platform designed to enable accessible, objective sports talent assessment through smartphone-based video analysis. The proposed system integrates computer vision, pose estimation, machine learning, and cloud-based analytics to evaluate athletic performance without specialised equipment or professional evaluation centres. Athletes perform predefined fitness activities that are recorded using mobile devices, after which movement features are extracted and analysed to generate performance scores, rankings, and feedback. The platform also provides secure data storage, progress tracking, and comparative benchmarking across age groups and regions. Experimental evaluation demonstrates that the system can successfully process smartphone-recorded videos and produce consistent performance assessments, thereby reducing reliance on subjective judgment. The generated rankings and analytics support data-driven decision-making for athletes, coaches, and sports administrators. By combining lightweight Artificial Intelligence models with mobile computing and cloud infrastructure, KhelQuest offers a scalable, transparent, and cost-effective solution for grassroots sports development. The study concludes that smartphone-based Artificial Intelligence systems can significantly improve the accessibility, fairness, and efficiency of sports talent identification and performance monitoring, thereby contributing to a more inclusive and technology-enabled sports ecosystem.

***Keywords*:** Artificial Intelligence, Sports Analytics, Talent Identification, Computer Vision, Pose Estimation, Machine Learning, Mobile Computing, Performance Assessment

## 1. Introduction

Sports play an important role in promoting physical fitness, mental well-being, discipline, teamwork, and leadership skills. Beyond individual development, sports also contribute significantly to social progress and national growth. However, access to quality sports training, talent identification programs, and performance evaluation opportunities remains uneven across different regions and socio-economic groups. Traditional talent scouting methods often rely on centralised trials, professional coaches, specialised equipment, and dedicated training facilities, making the process costly and inaccessible for many aspiring athletes. As a result, talented individuals from rural and underprivileged communities may remain undiscovered despite possessing significant athletic potential [5].

Recent advancements in Artificial Intelligence (AI), Computer Vision, and Machine Learning (ML) have created new opportunities for transforming sports analytics and athlete development. AI-powered systems can analyse athletic movements, evaluate performance metrics, and generate objective feedback based on measurable parameters. Computer vision techniques such as pose estimation enable accurate tracking of human body movements from video recordings without requiring expensive motion-capture systems or wearable sensors.


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Furthermore, the increasing computational capabilities of smartphones have enabled sophisticated sports analysis on widely available mobile devices, thereby improving the accessibility and scalability of sports assessment solutions [1], [2], [15].

Despite these technological advancements, most existing AI-based sports analytics platforms are designed primarily for professional athletes and controlled training environments. Many systems require high-end hardware, continuous internet connectivity, or specialised infrastructure, which limits their adoption in grassroots sports ecosystems. In addition, existing solutions often focus only on performance analysis and do not provide a unified environment that connects athletes, coaches, and sports organisations while supporting transparent talent identification and long-term athlete development. This creates a significant gap between technological innovation and its practical application in inclusive sports development [4], [5], [7].

To address these challenges, this paper proposes **KhelQuest**, an AI-powered platform designed to democratize sports talent assessment and athlete development. The platform utilises smartphone-based video analysis, pose estimation, machine learning models, and cloud analytics to objectively and efficiently evaluate athletic performance. By employing lightweight AI models optimised for mobile devices, the system enables performance assessment even in resource-constrained and low-connectivity environments [10], [11].

The major contributions of this work include the development of a smartphone-based AI framework for automated sports performance evaluation, the integration of computer vision and machine learning techniques for objective talent identification, the deployment of lightweight models suitable for low-end mobile devices, and the provision of cloud-based analytics, ranking, and progress-tracking mechanisms. By emphasising accessibility, fairness, scalability, and transparency, KhelQuest aims to bridge the gap between advanced sports analytics and grassroots sports development, creating equal opportunities for athletes regardless of their geographic or economic background [1], [7], [15].

## 2. Research Methodology

The methodology adopted in this study focuses on developing an accessible and objective sports talent assessment framework using smartphone-based video analysis and artificial intelligence techniques. The proposed KhelQuest platform integrates computer vision, pose estimation, machine learning, and cloud-based analytics to evaluate athlete performance in a structured and scalable manner. The overall workflow consists of data acquisition, pose extraction, feature analysis, performance evaluation, and result management [2], [8].

### Data Acquisition:

The process begins with athletes performing predefined fitness assessments such as push-ups, squats, and vertical jumps. These activities are recorded using smartphone cameras, eliminating the need for specialised motion-capture systems or wearable devices. The recorded videos serve as the primary input for the evaluation process. Basic user information and test metadata are also collected and linked to the corresponding assessment session to ensure proper identification and tracking of performance records.

### Pose Estimation and Feature Extraction

After video acquisition, computer vision techniques are applied to extract human body keypoints from each video frame. The system uses pose estimation methods to identify and

track skeletal joint positions, including shoulders, elbows, hips, knees, and ankles. Similar pose-based activity recognition approaches have been widely used for human movement analysis and exercise recognition [2], [8], [9]. The extracted skeletal information is then processed to derive relevant movement features, including joint angles, body alignment, repetition counts, movement consistency, and execution speed.

### AI-Based Performance Evaluation

The extracted features are analysed using machine learning models to objectively evaluate athlete performance. The evaluation framework focuses on measurable indicators such as movement accuracy, posture correctness, repetition quality, and consistency rather than subjective human judgment. Lightweight machine learning techniques are employed to ensure efficient execution on mobile devices with limited computational resources [10], [11]. This approach enables real-time or near-real-time performance assessment while maintaining acceptable accuracy levels.

### Validation and Score Generation

To improve reliability, the system incorporates validation mechanisms that identify incomplete movements, abnormal motion patterns, and inconsistent exercise execution. These validation checks help ensure that performance scores are generated only from valid activity recordings. Based on the analysed movement features, the system calculates performance scores and generates structured feedback. The evaluation process aims to provide fair and standardised assessment across athletes regardless of geographical location or access to professional coaching facilities [1], [7].

### Cloud Storage and Analytics

The final stage involves storing performance results in a secure cloud-based database. Cloud integration enables long-term athlete performance tracking, comparative ranking, and dashboard-based analytics. Coaches and administrators can utilise these analytics to monitor athlete progress, identify improvement trends, and support evidence-based decision-making [5]. Secure data management practices are incorporated to ensure privacy, controlled access, and responsible handling of athlete information [6].

The proposed methodology combines established computer vision and machine learning techniques with mobile computing and cloud analytics to create a scalable and inclusive sports talent assessment platform. By reducing dependence on expensive infrastructure and manual evaluation, the framework supports fair and accessible athlete development across diverse environments.

## 3. Theory and Calculation

The proposed KhelQuest platform is built on the principles of computer vision, human pose estimation, and machine learning-based performance evaluation. The theoretical foundation of the system lies in the ability of pose estimation models to represent human movement through a set of skeletal keypoints corresponding to major body joints such as the shoulders, elbows, hips, knees, and ankles. By transforming video frames into skeletal representations, the system can analyse movement patterns independently of background conditions and visual distractions. This approach enables objective assessment of athletic activities using only smartphone-recorded videos.

Human movement analysis is performed by tracking the spatial and temporal variations of skeletal keypoints across consecutive video frames. The extracted coordinates provide information about posture, body alignment, range of motion, and movement consistency. These parameters are important indicators of athletic performance and form the basis for automated

evaluation. Unlike traditional observation-based assessment methods, pose-based analysis relies on measurable biomechanical features, thereby reducing subjectivity and improving evaluation consistency.

To quantify movement quality, joint angles are calculated using the coordinates of adjacent body joints. For three skeletal points A, B, and C, the angle formed at point B can be determined using geometric relationships between the corresponding coordinate positions. Joint angle measurements help assess posture correctness, movement depth, and execution accuracy during physical activities. Similarly, repetition count and movement consistency are derived from periodic variations in joint trajectories observed throughout the activity duration.

Machine learning models then process the extracted movement features to generate performance evaluations. The assessment framework considers multiple performance indicators, including technique, consistency, accuracy, and endurance. These indicators are combined to produce an overall performance score using a weighted evaluation approach:

**Performance Score = (0.30 × Technique) + (0.25 × Consistency) + (0.25 × Accuracy) + (0.20 × Endurance)**

where $w_1$, $w_2$, $w_3$, and $w_4$ represent the relative weights assigned to each evaluation criterion. The weighting mechanism allows the system to emphasise specific performance attributes depending on the type of fitness assessment being conducted.

The final calculated score is normalised and used for ranking, benchmarking, and progress tracking. This theoretical framework enables KhelQuest to provide objective, scalable, and data-driven sports talent assessment while maintaining compatibility with resource-constrained mobile environments.

## 4. Results and Discussion

### 4.1 Results

The proposed KhelQuest platform was successfully implemented and evaluated using smartphone-recorded fitness assessment videos. The system analysed athlete movements, extracted pose-based features, generated performance scores, and produced comparative rankings without requiring specialised sensors or laboratory infrastructure. The generated rankings were categorised at global, state, and age-group levels, enabling athletes to benchmark their performance against relevant peer groups.

The platform demonstrated the ability to differentiate athlete performance based on movement quality, consistency, and execution accuracy. Performance records were stored and visualised in the analytics dashboard, allowing users to track improvements over time. The ranking mechanism dynamically updates scores based on assessment outcomes, providing a transparent, structured evaluation process. These results demonstrate the practical feasibility of using AI-powered mobile systems for decentralised sports talent assessment.

### 4.2 Discussion

The findings indicate that integrating computer vision and machine learning techniques into a smartphone-based platform can significantly improve the accessibility of sports performance evaluation. Unlike traditional talent identification methods that rely heavily on expert observation and centralised trials, the proposed system provides objective assessment using measurable performance parameters. This reduces the influence of subjective bias and promotes fairness in athlete evaluation [3], [7].

A major advantage of KhelQuest is its ability to operate using consumer-grade mobile devices. Previous studies have demonstrated the effectiveness of pose estimation and video-based

activity recognition for movement analysis; however, many existing solutions focus only on activity classification or controlled experimental settings [2], [8], [9]. In contrast, the proposed platform extends these capabilities by integrating automated scoring, athlete ranking, cloud-based analytics, and long-term performance monitoring within a single ecosystem.

The ranking and benchmarking features provide additional value by encouraging athlete engagement and continuous improvement. Through comparative performance analysis, athletes can identify strengths and areas requiring development, while coaches can use analytics dashboards to support evidence-based training decisions. Similar cloud-based sports management systems have been reported in previous research, but many are designed for professional sports organisations and may not adequately support grassroots deployment [5]. KhelQuest addresses this limitation by focusing on accessibility, affordability, and scalability.

Furthermore, the use of lightweight AI models enables efficient execution on resource-constrained smartphones, making the platform suitable for rural and low-connectivity environments [10], [11]. Although the current implementation focuses on selected fitness assessments, the results suggest that the framework can be extended to support multiple sports disciplines and larger athlete populations. Overall, the findings demonstrate that KhelQuest successfully bridges the gap between advanced sports analytics and practical grassroots talent identification, contributing toward a more inclusive and data-driven sports ecosystem [1], [15].

## 5. Preparation of Figures and Tables

Figures and tables are used throughout this study to illustrate the architecture, workflow, implementation, and performance analysis of the proposed KhelQuest platform. These visual elements help in understanding the interaction between different system components and the overall evaluation process.

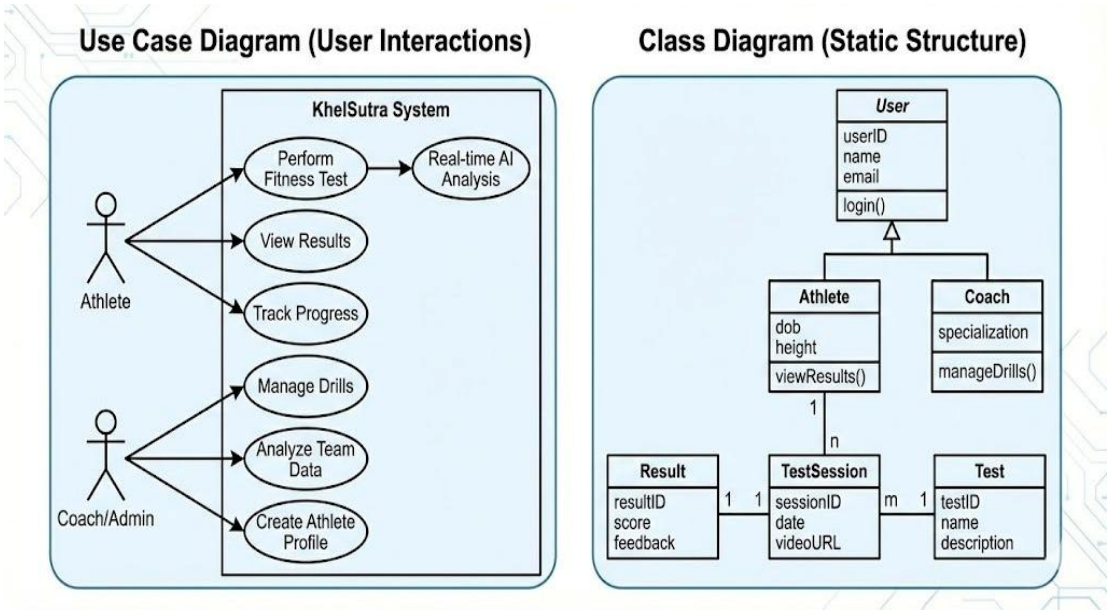


**Fig. 1 System Architecture**

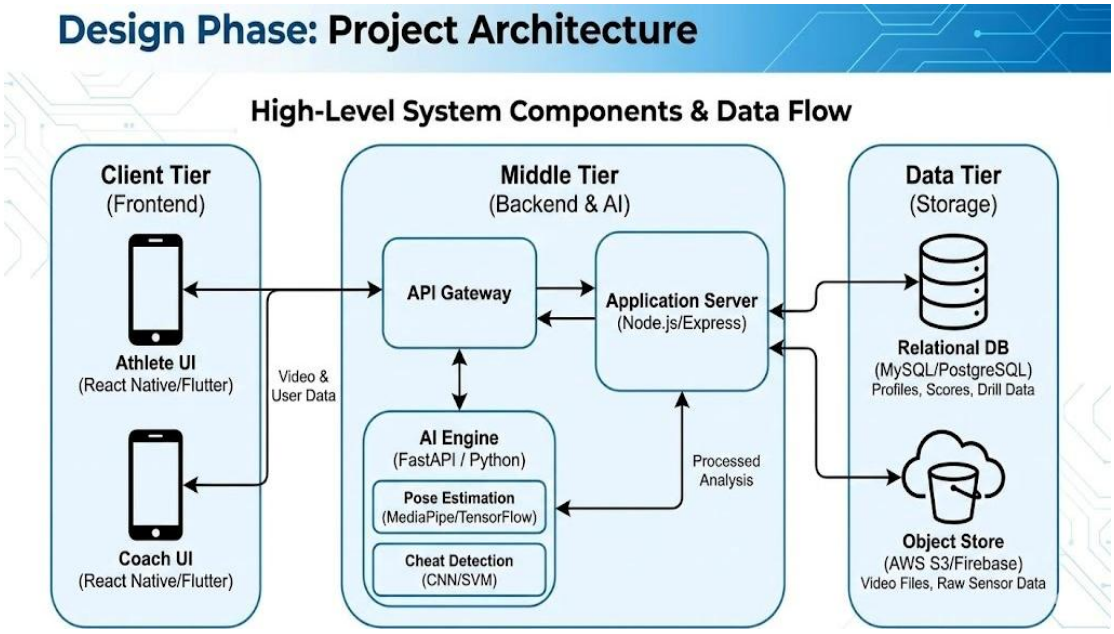


**Fig. 2 System Model**

**Figure 1** presents the system architecture of KhelQuest, showing the interactions among the mobile application, the artificial intelligence engine, the backend services, and the cloud database. The architecture highlights the flow of data from video acquisition to performance analysis and result generation.

**Figure 2** illustrates the system model using use case and class diagrams. The use case diagram describes the interactions among athletes, coaches, and the platform, while the class diagram depicts the system's core entities and their relationships.

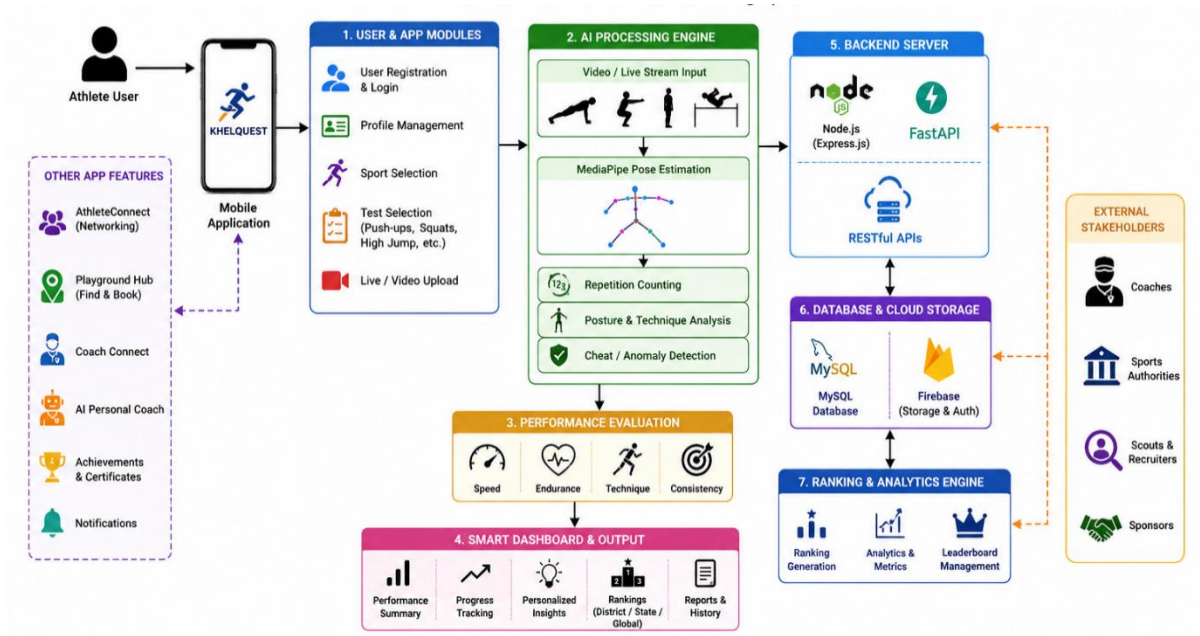


**Fig. 3 System Flow and Implementation**

**Figure 3** depicts the workflow for implementation, including user registration, role selection, test execution, artificial intelligence-based analysis, and result generation. This figure demonstrates the sequence of operations performed during athlete assessment.

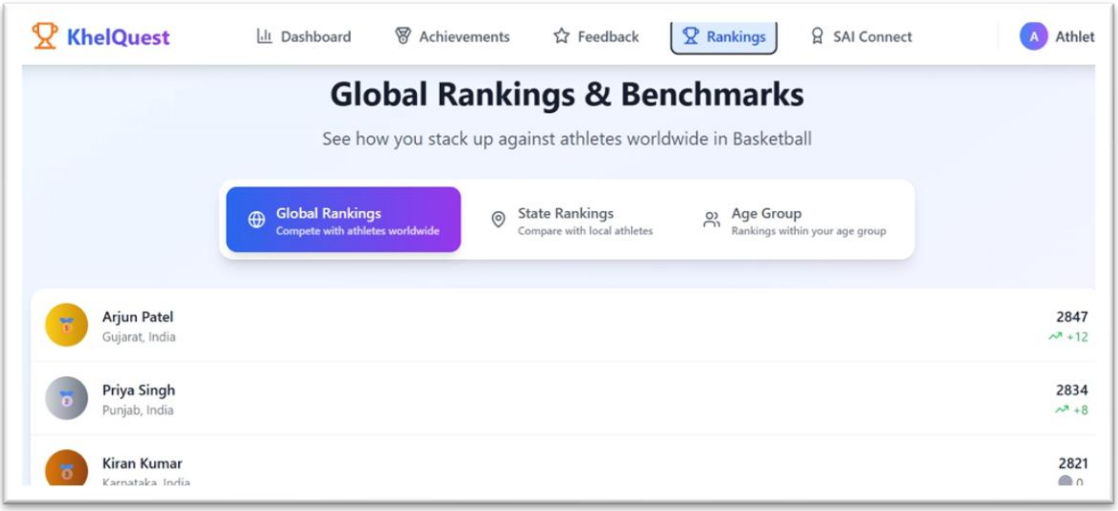


**Fig. 4 Dashboard Analytics**

**Figure 4** shows the analytics dashboard and ranking interface generated by the platform. The dashboard provides athlete rankings, performance scores, and progress-tracking information, enabling transparent performance evaluation and comparison.

**Table 1. Comparative Analysis of Existing Works and Proposed System**

| Ref. | Methodology | Technology | Deployment | Limitation | KhelQuest Advantage |
|---|---|---|---|---|---|
| [1] | Survey-based review of AI in sports | General ML and analytics models | Conceptual research studies | No real-world system implementation | Provides practical mobile-based system |
| [2] | Video-based ML performance evaluation | Computer vision + ML classification | Controlled indoor setups | Limited scalability discussion | Works with smartphone videos in field |
| [3] | Deep learning for talent detection | CNN/DNN trained on labeled datasets | Structured dataset environments | High dataset dependency | Operates on real-world recordings |
| [4] | Lightweight model optimization for edge | TinyML and quantized networks | Low-resource embedded devices | Performance trade-offs in scaling | Combines lightweight AI with cloud support |
| [5] | Cloud-based sports analytics dashboards | Web systems + database analytics | Professional sports institutions | Not designed for grassroots usage | Targets rural and decentralized athletes |
| [6] | Secure data management framework | Encryption and cloud authentication | Mobile health applications | Not sports-specific | Integrates security into sports workflow |
| [7] | Fairness and bias analysis in AI | Bias detection and transparency models | Theoretical research focus | Limited practical integration | Implements fairness in scoring system |
| [8] | Pose-based activity recognition | Skeletal tracking + vision models | Specific exercise tracking | Only classification, no ranking | Adds scoring and benchmarking |
| [9] | Vision-based activity recognition | Deep CNN pose modeling | Controlled validation datasets | Sensitive to environment changes | Designed for real-world field usage |
| [14] | Video tampering detection framework | Deep learning + multimedia forensics | Digital content verification | High computational complexity | Lightweight anti-cheating validation |
| **Proposed** | End-to-end AI sports assessment pipeline | Pose + ML + Cloud + Mobile | Grassroots, decentralized environments | Depends on video quality conditions | Integrated, scalable, inclusive ecosystem |

**Table 1** presents a comparative analysis of existing sports analytics approaches and the proposed KhelQuest system. The comparison highlights differences in methodology, technology focus, deployment context, limitations, and the unique contributions of the proposed framework. The table demonstrates how KhelQuest combines mobile computing, pose estimation, machine learning, and cloud analytics within a single integrated platform designed for grassroots sports development.

All figures and tables are placed close to the relevant discussion in the manuscript and are appropriately referenced within the text to improve clarity and readability.

## 6. Conclusions

This study presented KhelQuest, an Artificial Intelligence-powered platform designed to improve accessibility, transparency, and efficiency in sports talent identification and performance assessment. The proposed system combines smartphone-based video analysis, computer vision, machine learning, and cloud analytics to create an integrated framework capable of evaluating athlete performance without the need for expensive infrastructure or specialised equipment. The implementation demonstrates that objective performance assessment can be achieved using consumer-grade mobile devices, making the solution suitable for grassroots and resource-constrained environments. Through automated movement analysis, performance scoring, ranking, and progress tracking, the platform provides athletes, coaches, and sports administrators with meaningful insights that support informed decision-making and long-term athlete development. The results indicate that the proposed approach can reduce reliance on subjective evaluation methods while promoting fairness and consistency in talent identification. In addition, integrating cloud-based analytics enables efficient data management and comparative performance monitoring across age groups and regions. Despite these advantages, the current system is limited to selected fitness-based assessments, and its performance may be influenced by factors such as camera positioning, lighting conditions, and recording quality. Furthermore, large-scale validation across diverse athlete populations and multiple sports disciplines is required further to assess the robustness and generalizability of the framework. Future enhancements may include support for additional sports, integration of wearable sensor data, advanced predictive analytics, explainable artificial intelligence mechanisms, and improved anti-cheating techniques to strengthen system reliability. Overall, KhelQuest demonstrates the potential of combining artificial intelligence and mobile technologies to create a scalable, inclusive sports ecosystem that expands opportunities for talent discovery, performance evaluation, and athlete development, while contributing to a more equitable, technology-driven sports environment.

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## Conflict of Interest

The authors declare no conflict of interest.

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