SIN-CHN SCIENTIFIC PRESS PTE.LTD.

Molecular & Cellular Biomechanics 2025, 22(3), 1160.
https://doi.org/10.62617/mcb1160

Article

Application of sports sensors in motion correction in competitive sports

Chenggong Yin, Lijie Wang*

College of General Education, Guangxi Vocational and Technical College of Industry and Commerce, Nanning 53008, China
*** Corresponding author:** Lijie Wang, 13517687469@163.com

CITATION

Yin C, Wang L. Application of sports sensors in motion correction in competitive sports. Molecular & Cellular Biomechanics. 2025; 22(3): 1160.
https://doi.org/10.62617/mcb1160

ARTICLE INFO

Received: 18 December 2024
Accepted: 27 December 2024
Available online: 13 February 2025

Abstract: This study aims to explore the application of sports sensors in motion correction within competitive sports, providing both theoretical and practical guidance. With the advancement of technology, sensor technology is increasingly being applied in sports training and competition, aiding athletes and coaches in more accurately analyzing movements, enhancing performance, and reducing injury risks. The research employs both qualitative and quantitative methods to collect and analyze data from athletes during training and competition, examining the roles of sensors in stride length, stride frequency, posture analysis, and real-time feedback. Additionally, through the formulation of personalized training plans and injury prevention strategies, the study showcases the practical effects of sensors in various sports disciplines. The findings indicate that sensor technology significantly improves movement optimization, injury prevention, and performance enhancement. However, the study also highlights challenges in data collection and analysis, suggesting future research to expand data samples and improve analysis models. This research not only offers new perspectives for theoretical exploration but also provides concrete guidance for practical applications, thus holding substantial practical significance.

Keywords: sports sensors; competitive sports; motion correction; injury prevention; real-time feedback

1. Introduction

1.1. Research background

In recent years, with the rapid advancement of technology, the application of sports sensors in competitive sports has become increasingly widespread. These sensors, through their high-precision technology, can assist coaches and athletes in precisely analyzing sports data, thereby enhancing athletic performance and reducing injury risks. The origin of sports sensors can be traced back to the mid-20th century, where their initial applications focused mainly on simple mechanical sensors used to measure basic parameters in sports, such as speed and distance. With the development of electronic and computer technologies, sensors have gradually become more sophisticated and precise. Modern accelerometers and gyroscope sensors, for instance, can capture high-frequency movement data and record athletes' actions with great accuracy [1].

Sensor technology is widely applied in competitive sports. For example, in running training, athletes use smartwatches and shoe sensors to monitor stride length, stride frequency, and running posture in real time, helping them optimize their running technique. In swimming training, sensors embedded in swim caps or goggles can record stroke frequency and force, enabling coaches and athletes to analyze swimming efficiency and propose improvement strategies. Furthermore, in team sports such as

soccer and basketball, sensors can track players' movement trajectories, speed, and passing accuracy, thereby enhancing team coordination and tactical execution.

Moreover, sports sensors play a crucial role in injury prevention. By monitoring athletes' movements and physical status, sensors can promptly detect and correct potentially harmful actions. For example, the overuse of specific muscle groups or incorrect exercise postures can be quickly identified through sensor data, allowing for corrective measures to be taken to reduce injury risks [2].

Overall, the application of sports sensors in competitive sports not only helps improve athletic performance but also reduces injury risks and extends athletes' careers. By thoroughly analyzing the origin, development, and significance of sports sensors in competitive sports, this study lays a solid foundation for further exploration.

1.2. Research objectives

This study aims to systematically explore the application of sports sensors in motion correction within competitive sports, proposing effective methods and strategies to help athletes optimize their movements, enhance performance, and prevent injuries. The specific objectives include understanding the current state of sensor applications in various sports through surveys and literature analysis, gaining detailed insights into the usage of sports sensors in various competitive sports such as running, swimming, soccer, and basketball. The research will analyze how sensors are used, methods of data collection, and their actual effects, thereby understanding the application of sensors in real training and competition scenarios.

Through experiments and data analysis, the study will evaluate the specific effectiveness of sports sensors in correcting athletes' movements. It will examine the impact of sensor technology on improving the accuracy of athletes' technical movements, reducing errors, and enhancing overall performance, with a focus on the role of real-time feedback and personalized training provided by sensors in motion correction.

Based on the analysis of the current state and effectiveness of sensor applications, the study will propose optimization and improvement suggestions for different sports and application scenarios. This includes how to select and configure sensors, how to combine traditional training methods with motion correction, and how to utilize sensor data to formulate personalized training plans. By offering practical recommendations, the study aims to help coaches and athletes better leverage sensor technology to improve training effectiveness and performance.

The study also explores the role of sports sensors in injury prevention, monitoring athletes' movement data and physical condition to identify and prevent potential injuries. It investigates how sensor technology can be used for injury risk assessment and the development of preventive measures, thereby reducing injury risks and ensuring athletes' health and career longevity.

Through systematic research and application examples, this study aims to promote the broader application of sports sensors in competitive sports, providing a theoretical and practical foundation for the dissemination of sensor technology. The study seeks to enhance the application and development of sensor technology in sports science research and athletic training.

1.3. Significance of the study

By systematically exploring the application of sports sensors in motion correction within competitive sports, this study aims to provide theoretical and practical references for athletes, coaches, and researchers, thereby promoting further application of sensor technology in sports and bringing numerous benefits. Detailed analysis of how sensor technology can optimize movements, improve performance, and effectively prevent sports injuries in different sports disciplines demonstrates that this study can significantly enhance athletic performance [3]. Through precise analysis and correction of movements, sensor technology can help identify subtle defects in technical movements and provide real-time feedback, enabling athletes to quickly adjust their actions and improve efficiency. Sports such as running, swimming, soccer, and basketball can benefit from detailed analysis and improvement of stride length and frequency, stroke frequency and force, and passing and running techniques, thereby continually optimizing movements and enhancing competitive performance.

In terms of injury prevention, the study has considerable significance. By monitoring athletes' physical conditions and movements in real-time, sensors can identify potential injury risks. For instance, when deviations from normal movement patterns or excessive loads are detected, the sensors can promptly issue warnings, reminding athletes and coaches to take protective measures to avoid injuries. The study also contributes to the formulation of personalized training plans. Given that each athlete's physical condition, technical level, and training needs vary, sensor technology can collect detailed movement data, analyze movement characteristics and training requirements, and formulate personalized training plans to maximize athletes' potential. Additionally, this study can enhance coaches' training effectiveness. Sensor technology can provide accurate and detailed sports data, helping coaches understand athletes' training status and technical levels. By analyzing data to identify deficiencies in movements, coaches can offer targeted guidance and adjustments, improving training outcomes. For instance, in basketball training, sensor data can help coaches analyze shooting postures and running routes, thereby optimizing tactical arrangements and technical guidance.

Through systematic research and application examples, this study can provide both theoretical and practical foundations for the widespread application of sensor technology in sports. The research findings can serve as references for companies and research institutions developing new sensor technologies, promoting innovation and advancement in sensor technology [4]. It can also offer new research directions for sports science researchers, driving the development and progress of sports science. In summary, by systematically exploring the application of sports sensors in motion correction within competitive sports, this study can enhance athletic performance, prevent sports injuries, formulate personalized training plans, improve coaching effectiveness, and promote the application and development of sensor technology in sports science. This contributes to the improvement of competitive sports levels and ensures athletes' health and career longevity.

2. Research methodology

2.1. Research design

This study employs a combination of qualitative and quantitative research methods, including literature review, field surveys, and experimental validation, to systematically explore the application of sports sensors in motion correction. The specific research design and methods are as follows:

2.2. Literature review

- Objective: To comprehensively review existing research on the application of sports sensors in competitive sports, identifying research gaps and areas needing further investigation.
- Method: Collect relevant literature from academic databases, professional journals, conference papers, and related books. Conduct comparative analyses of different studies' conclusions, extracting valuable information pertinent to this research. The literature review will focus on the application of sensor technology in motion correction, performance optimization, and injury prevention.

2.3. Field surveys

- Objective: To understand the current application status of sports sensors in actual training and competition, gathering real-world data and feedback.
- Method: Select several representative sports (such as running, swimming, soccer, and basketball) for interviews and questionnaire surveys with athletes, coaches, and relevant technical staff (see **Figure 1**). Survey topics include sensor usage, application effectiveness, existing issues, and improvement suggestions. The survey results will be used to validate conclusions from the literature review and provide a basis for experimental design.

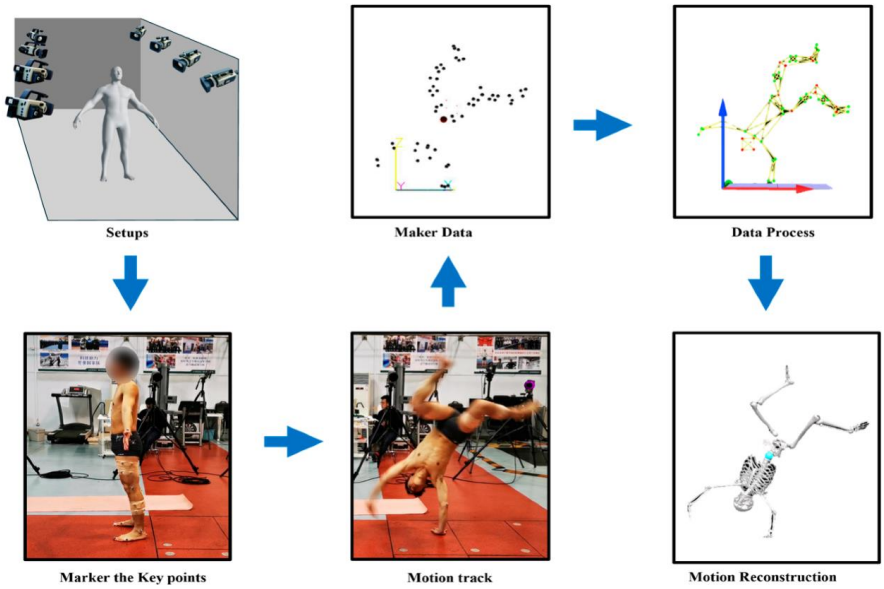

Figure 1. Workflow of motion sensors.

Source: Suo et al. [5].

2.4. Experimental validation

1) Objective: To verify the specific effects and application value of sports sensors in motion correction through practical experiments.
2) Preliminary preparation:
   - Based on literature analysis and field research results, determine the specific objectives and methods of the experiment.
   - Select appropriate sensor equipment, such as accelerometers, gyroscopes, and force sensors, which can accurately capture the athletes' motion data.
   - Develop a detailed experimental plan, including the schedule, venue arrangement, and participants.
3) Experimental implementation:
   - During actual training and competitions, athletes wear the selected sensors to collect motion data in real time.
   - Coaches and technicians analyze the motion data and provide feedback to develop personalized training plans.
   - Specific steps include:

Wearing sensors: Athletes wear smartwatches, sole sensors, swim cap sensors, etc., during training and competitions to collect real-time data on stride length, stride frequency, posture, stroke frequency, force, etc.

Using visualization tools and software, data is fed back to coaches and athletes in real time to help them adjust their movements.

4) Data analysis:
   - Use data analysis libraries in MATLAB and Python to process and analyze the data collected during the experiment.
   - Specific steps include:

Data organization: Preprocess collected data to remove noise and outliers.

Data analysis: Analyze the changes in athletes' data before and after the experiment to evaluate the effectiveness of sensor technology in improving athletic performance and preventing injuries.

Result comparison: Compare the motion data before and after the experiment, such as stride length, stride frequency, stroke frequency, and force, to draw conclusions.

5) Result verification:
   - Verify the reliability and generality of the conclusions through repeated experiments.
   - Specific steps include:

Repeated experiments: Conduct multiple experiments at different times and conditions to ensure data stability and reliability.

Data summary: Summarize data from multiple experiments to identify commonalities and differences.

Method optimization: Adjust and optimize the use of sensors based on experimental results to ensure the broad applicability of the conclusions.

3. Application of sports sensors

3.1. Motion analysis

The application of sports sensors in analyzing athletes' movements is extensive, including data acquisition and analysis of stride length, stride frequency, posture, and more. During sports activities, sensor devices such as accelerometers, gyroscopes, and force sensors are installed on the athlete's body parts or equipment. For instance, sole sensors or smartwatches can record the length and frequency of each step in real-time. By detecting the foot's acceleration and contact time with the ground, stride length and frequency can be calculated. Sensors installed on the waist, back, or limbs capture changes in the athlete's posture, measure the tilt angles, and trace the motion of different body parts, which helps in analyzing the stability and accuracy of posture. In swimming training, sensors attached to swim caps or goggles can record the frequency and force of each stroke, evaluating the efficiency of the stroke.

The collected data is processed and analyzed using data analysis software such as MATLAB, Python, or specialized sports analysis software. Specific analysis steps include denoising and normalizing the raw data, removing outliers to ensure accuracy and consistency. Key features such as average stride length, stride frequency, and stroke force are extracted from the preprocessed data. Comparing these feature parameters can reveal deficiencies in the athlete's movements. Machine learning algorithms are used to classify and cluster the data, identifying different motion patterns. For example, through clustering analysis, athletes' movements can be categorized into different types, identifying unstable or irregular movements [6].

Practical applications include using sole sensors in running training to record the stride length and frequency. Data analysis results may indicate excessively high stride frequency and short stride length. Coaches can use this data to guide athletes in adjusting their stride length and frequency to improve running efficiency. In swimming training, force sensors in swim caps can record the force and frequency of each stroke. Data analysis may show uneven force application, prompting coaches to guide adjustments in stroke technique. For posture correction, sensors on the waist and back capture posture changes (**Figure 2**), with data analysis indicating instability in certain movements. Coaches can use this information to instruct athletes in strengthening core training to improve posture stability.

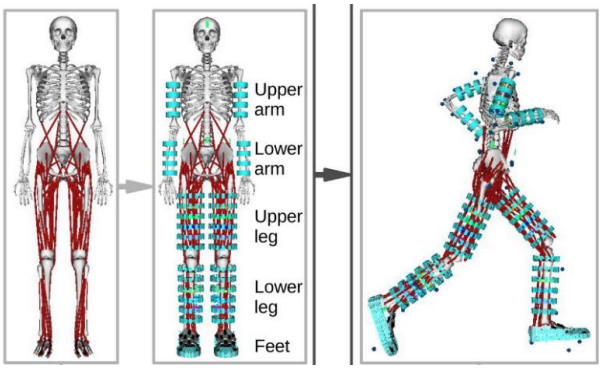

Figure 2. Human motion analysis using personalized biomechanical models, simulation, and data synthesis to estimate wearable system and marker performance.
Source: Derungs and Amft [7].

3.2. Feedback systems

Sports sensors help athletes promptly adjust their movements during training and competitions through real-time feedback systems, thus enhancing efficiency and performance. Common feedback systems include visual feedback, audio feedback, and tactile feedback.

Visual feedback systems display real-time movement data through screens, mobile applications, or wearable device interfaces, aiding athletes in understanding and adjusting their state. For instance, runners use smartwatches to view stride length, stride frequency, and heart rate data, while swimmers see stroke frequency and force on displays integrated into their goggles.

Audio feedback systems provide real-time audio prompts through headphones or speakers, guiding athletes to adjust their movements. For example, during running training, athletes wear headphones with voice coaching features, and in strength training, coaches provide immediate voice guidance through speakers [8].

Tactile feedback systems use vibrations or other tactile signals to prompt athletes to adjust their movements in real time. For instance, cyclists use handlebar vibration devices to sense if their riding posture is correct, and gymnasts wear clothing with vibration functions that alert them to correct their posture when movements are improper.

In running training, the combination of smartwatches and voice-guided headphones displays and prompts real-time stride frequency, stride length, and heart rate data, helping athletes maintain optimal performance. In swimming training, force sensors in swim caps record stroke frequency and force, while integrated displays in goggles provide real-time feedback, guiding athletes to adjust their stroke techniques and improve swimming speed. In strength training, coaches use speakers to provide voice guidance, adjusting athletes' posture and force based on real-time data to ensure effective training [9].

Real-time feedback systems are crucial for motion correction. They help athletes promptly identify and correct deficiencies in their movements, enhancing technical skills and performance. Additionally, these systems effectively prevent sports injuries by prompting athletes to adjust their movements, reducing the risk of injury due to incorrect actions. Finally, feedback systems enhance training efficiency, enabling coaches and athletes to precisely develop and adjust training plans, thus maximizing training outcomes.

3.3. Injury prevention

Sensors play a crucial role in identifying potential injury risks. Sports sensors can monitor athletes' movements in real time, capturing every minute detail. These sensors include accelerometers, gyroscopes, and force sensors, which are capable of recording parameters such as speed, acceleration, angular velocity, and the forces applied by the athlete. By analyzing this data, it is possible to identify instabilities and abnormal variations in the athlete's movements. For instance, during running training, if sensors detect excessive force or incorrect angles upon foot landing, it could indicate a potential injury risk [10].

In addition to movement monitoring, sensors can also track the athlete's

physiological state, such as heart rate, breathing frequency, and muscle activity. These sensors include heart rate monitors and electromyography sensors. By monitoring and analyzing these physiological data, it is possible to identify fatigue and overexertion during intense training or competitions. For example, heart rate monitors can detect changes in heart rate; if the heart rate is excessively high, it may indicate over-fatigue, signaling the need for rest and adjustment of training intensity [11].

During running training, athletes wear sole sensors that monitor the force and angle of each step. When sensors detect excessive force or incorrect angles upon landing, alerts are sent via smartwatches or headphones, prompting the athlete to adjust their stride to prevent injuries such as ankle or knee damage due to prolonged incorrect posture. In strength training, athletes wear electromyography sensors that monitor muscle activity. When sensors detect excessive muscle tension or uneven force application, they provide alerts through vibration devices or voice prompts, reminding athletes to adjust their movements and force to avoid muscle strains or joint injuries. In swimming training, force sensors in swim caps or goggles monitor the force and frequency of each stroke [12]. When detecting uneven stroke force or abnormal frequency, sensors provide alerts via display screens or headphones, prompting swimmers to adjust their stroke techniques to prevent overuse injuries in the shoulders and arms.

3.4. Personalized training

Personalized training is based on the athlete's individual data, tailored to maximize training effectiveness and athletic performance. By using sensor technology, coaches and athletes can collect and analyze detailed personal movement data, allowing them to develop training plans that meet the unique needs of each athlete. During training, athletes wear devices such as smartwatches, heart rate monitors, accelerometers, and gyroscopes to collect real-time data on stride length, stride frequency, heart rate, breathing frequency, force, speed, etc. This data is organized and analyzed using professional data analysis software (such as MATLAB or Python's data analysis libraries) to obtain insights into the athlete's performance and trends at different training stages [13].

Based on the collected movement data, initial assessments of the athlete's strengths and weaknesses are made. For example, by analyzing running data, it may be found that an athlete has a short stride length but high stride frequency, leading to the formulation of a training plan to increase stride length. In swimming training, heart rate monitors and force sensors can record heart rate and stroke force in real-time; if the stroke force is uneven and heart rate fluctuates significantly, a training plan can be formulated to improve stroke efficiency and stabilize heart rate. Based on the assessment results, specific training goals are set for the athlete, such as improving stride length, enhancing cardiovascular function, and increasing muscle strength [14]. These goals are then used to develop specific training content and plans tailored to the individual's characteristics and objectives.

During training, sensors continuously monitor the athlete's performance, providing instant feedback data. Training plans are adjusted in real-time based on this feedback to ensure optimal training outcomes. For example, in running training,

adjustments to training intensity and content are made based on real-time heart rate and stride length data. In strength training, electromyography sensors monitor muscle activity; if certain muscle groups are found to be underutilized, coaches adjust movements and force based on real-time data and develop targeted training plans to strengthen specific muscle groups. Regular evaluations of the athlete's training effectiveness are conducted, analyzing data changes, and adjusting training goals and content [15]. These dynamic adjustments ensure that personalized training achieves the best possible results.

4. Case summary

In practical cases, we have accumulated a wealth of valuable data and experience through the application of sensor technology in various sports activities. These experiences and lessons provide valuable references for future research and applications. In running, swimming, and strength training, sensor devices such as smartwatches, sole sensors, heart rate monitors, and force sensors have achieved precise monitoring of athletes' movements and physiological data. For example, by real-time monitoring of stride length and frequency data in running athletes, we successfully helped athletes optimize their running posture, improving training efficiency and competition performance. Tailoring training plans based on athletes' personal data has yielded significant results. For instance, in swimming training, sensor data analysis was used to address issues of uneven stroke force, resulting in training plans that improved stroke efficiency and stabilized heart rates, effectively enhancing athletic performance [16].

However, some challenges and lessons were encountered in practice. For example, in some application cases, sensor data was affected by external interference and noise, leading to inaccuracies. In outdoor running training, environmental noise and interference signals impacted the accuracy of heart rate monitors, affecting training outcomes. This requires further improvement in the anti-interference capability of sensors and the precision of data processing algorithms. Although personalized training plans have shown some success, there was insufficient flexibility in some plans to respond promptly to changes in athletes' conditions [17]. For example, during high-intensity training phases, some athletes could not complete the predetermined training plan due to fatigue, resulting in decreased training effectiveness. This highlights the need to include flexible adjustment mechanisms in personalized training plans to ensure they can dynamically adapt to athletes' real-time conditions.

To further optimize the application of sensor technology in sports, improving athletes' training effectiveness and performance, we recommend improvements in data collection, training plan development, and athlete capability enhancement. First, by optimizing the design of sensor devices and data processing algorithms, we can improve the accuracy and stability of data, reducing the impact of external interference and noise. Second, when developing personalized training plans, consider the athlete's real-time condition and potential changes, incorporating flexible adjustment mechanisms to ensure training plans dynamically adapt to athletes' needs. Finally, while using sensor technology, emphasize developing athletes' awareness and

adjustment capabilities of their movements, gradually reducing reliance on technology, and enhancing athletes' self-regulation abilities. By summarizing the successful experiences and lessons from practical cases, we can provide valuable references for future research and applications.

5. Discussion

5.1. Research findings

Through a systematic exploration of the application of sports sensors in motion correction in competitive sports, we have found that sensor technology exhibits significant effectiveness in enhancing athletic performance, preventing sports injuries, and devising personalized training plans. Sensors can provide real-time monitoring and data analysis, helping athletes identify and correct deficiencies in their movements. For instance, in running training, they help optimize stride length and frequency to improve running efficiency; in swimming training, they aid in refining stroke techniques to enhance swimming speed. Sensor technology also proves effective in identifying potential injury risks and preventing sports injuries, such as real-time monitoring of muscle activity to prompt athletes to adjust their movements and avoid injuries. Furthermore, by collecting detailed motion data, coaches can develop personalized training plans for athletes, maximizing their potential [18].

However, this study also reveals some limitations of sensor technology. In practical applications, sensor data is susceptible to external interference and noise, leading to inaccuracies. Some athletes may become overly reliant on sensor technology, neglecting their ability to perceive and adjust their movements. This dependency could weaken athletes' self-regulation abilities. Additionally, the high cost of high-precision sensor equipment limits its widespread use among ordinary athletes and small clubs. The maintenance of sensor equipment and data analysis requires specialized knowledge and technical support, increasing complexity and cost. By improving the anti-interference capability of sensor equipment and the precision of data processing algorithms, reducing equipment costs, and focusing on developing athletes' self-perception abilities, the application effectiveness of sensor technology in sports can be further enhanced.

5.2. Theoretical significance

Through a systematic exploration of the application of sports sensors in motion correction within competitive sports, this study enriches the existing sports science theories. Traditional sports science research primarily relies on visual observation and manual evaluation to analyze athletes' movements. This method is often influenced by subjective factors and struggles to capture subtle movement details. With the introduction of sensor technology, sports science research can now base its analysis on objective data, allowing for precise analysis of athletes' technical movements, thereby enhancing the scientific rigor and reliability of the research [19]. This study, through empirical research, has verified the effectiveness of sensor technology across different sports disciplines, providing substantial data support and theoretical basis, thus offering a new perspective for the further development of sports science.

To address the limitations of existing analytical models in fully reflecting the dynamic performance of athletes, we propose the use of advanced machine learning techniques to identify patterns in noisy data and enhance prediction accuracy. By creating adaptive algorithms that adjust to individual athletes' biomechanics and training conditions over time, we can significantly improve the precision and relevance of insights derived. Furthermore, this study systematically analyzes the application of sensor technology in sports, particularly in motion correction, and explores how sensor technology can optimize athletic performance, prevent injuries, and develop personalized training plans. This analysis provides innovative theoretical viewpoints by comparing sensor data characteristics across different sports, identifying commonalities and differences in technical movements, and offering new perspectives for cross-sport research. Additionally, it proposes a real-time feedback and correction model based on sensor data, enriching the theoretical framework of sports science. These innovations not only deepen the understanding of sensor technology applications but also offer new approaches for interdisciplinary research in sports science and sensor technology [20].

As the existing analytical model may not fully reflect the dynamic performance of athletes and needs further optimization, we propose to use advanced machine learning techniques to identify patterns in noisy data and improve prediction accuracy. For example, utilizing machine learning algorithms can help uncover complex, non-linear relationships within the data that traditional analytical models might miss.

Furthermore, this study presents some innovative theoretical viewpoints. For instance, by comparing and analyzing the characteristics of sensor data across different sports, we identified commonalities and differences in technical movements among various sports, providing new perspectives for cross-sport scientific research.

Additionally, this study proposes a real-time feedback and correction model based on sensor data, further enhancing the theoretical system of sports science. Through these theoretical innovations, this research not only deepens the understanding of sensor technology applications but also offers new approaches for the interdisciplinary research of sports science and sensor technology.

5.3. Practical significance

This study provides athletes with detailed movement data through precise monitoring and analysis using sensor technology, helping them identify deficiencies in their technical movements and offering scientific guidance for coaches. Through real-time feedback systems, athletes can adjust their movements during training, improving their performance. For example, in running training, data on stride length and frequency recorded by sensors can help athletes optimize their running posture and improve efficiency; in strength training, electromyography sensors monitor muscle activity, reminding athletes to adjust their force to avoid injuries. The study results also have significant application value in injury prevention [5]. By monitoring the athletes' physical state and movements in real time, sensors can identify potential injury risks and promptly issue alerts, reminding athletes and coaches to take protective measures to reduce the occurrence of injuries and extend athletes' careers. For instance, heart rate monitors can issue alerts when detecting excessively high heart

rates, prompting athletes to rest appropriately; in swimming training, sensors monitoring stroke force and frequency help athletes adjust their movements to avoid overuse injuries in the shoulders and arms.

To address the limitations of existing sensor technologies, analytical algorithms, and sample sizes in fully reflecting the dynamic performance of athletes, we propose the use of advanced machine learning techniques to identify patterns in noisy data and enhance prediction accuracy. By creating adaptive algorithms that adjust to individual athletes' biomechanics and training conditions over time, we can significantly improve the precision and relevance of insights derived. Furthermore, this study systematically analyzes the application of sensor technology in sports, particularly in motion correction, and explores how sensor technology can optimize athletic performance, prevent injuries, and develop personalized training plans. By analyzing detailed movement data, coaches can tailor training programs to maximize athletes' potential, for instance, by increasing aerobic training for athletes with weaker cardiovascular function and strength training for those lacking muscle strength. These personalized training plans not only improve training outcomes but also better meet athletes' specific needs, enhancing their competitiveness and confidence [7]. In actual competitions, this personalized training method significantly improves overall athlete performance, providing crucial support for the development of competitive sports. In summary, this study, through the practical application of sensor technology in training and competitions, enhances athletes' training effectiveness and performance, prevents injuries, and devises scientific personalized training plans, offering specific and effective assistance and improvement suggestions for athletes and coaches. These practical significances promote the widespread application of sensor technology in sports, pointing to new directions for the development of sports science and technology.

6. Conclusion and prospects

6.1. Conclusion

This study systematically explored the application of sports sensors in motion correction within competitive sports, achieving significant results. Through comprehensive data collection and analysis, this research verified the effectiveness of sensor technology in improving athletic performance, preventing sports injuries, and developing personalized training plans. Specifically, sensor technology, through real-time monitoring and data feedback, helps athletes accurately identify and correct deficiencies in their technical movements, enhancing training efficiency and competition performance. Additionally, sensor technology plays a crucial role in identifying potential injury risks and preventing sports injuries, thereby ensuring athletes' health and prolonging their careers. Furthermore, personalized training plans based on sensor data enable coaches to provide more scientific guidance to athletes, improving training outcomes. The findings of this study enrich the existing sports science theories and lay a theoretical foundation for the widespread application of sensor technology in the sports field.

6.2. Research prospects

Although this study has made many important discoveries, there is still ample room for the development of sensor technology in sports. Future research could further enhance the anti-interference capabilities of sensor devices and the precision of data processing algorithms to ensure data accuracy and stability. Additionally, studies could explore the application of sensor technology in more sports disciplines, especially those with high technical demands and complex movements. As sensor technology continues to advance, its costs are expected to gradually decrease, enabling more athletes and training institutions to afford and benefit from this technology. Lastly, future research should focus on developing athletes' self-perception and adjustment abilities, reducing reliance on technology, and ensuring that athletes can maintain high levels of performance both with and without technological assistance. Through continuous innovation and research, the application of sensor technology in sports will deepen and expand, providing new momentum for the development of sports science and competitive sports.

Author contributions: Conceptualization, CY and LW; methodology, CY; software, CY; validation, CY and LW; formal analysis, CY; investigation, CY; resources, CY; data curation, CY; writing—original draft preparation, CY; writing—review and editing, CY; visualization, CY; supervision, CY; project administration, CY; funding acquisition, LW. All authors have read and agreed to the published version of the manuscript.

Ethical approval: Not applicable.

Conflict of interest: The authors declare no conflict of interest.

References

1. Anand A, Srivastava R, Prakash D, Kaligounder L, Sharma M. Wearable Motion Sensor Based Analysis of Swing Sports. IEEE. 2017. Available from: https://doi.org/10.1109/icmla.2017.0-149
2. Chen Z, Zhang G. CNN sensor based motion capture system application in basketball training and injury prevention. Prev Med. 2023;174:107644. Available from: https://doi.org/10.1016/j.ypmed.2023.107644
3. Gao H, Chen T. A flexible ultra-highly sensitive capacitive pressure sensor for basketball motion monitoring. Discov Nano. 2023;18(1). Available from: https://doi.org/10.1186/s11671-023-03783-y
4. Guelmami N, Mechraoui O, Fekih-Romdhane F, Bragazzi NL. Injury Prevention, Optimized Training and Rehabilitation: How Is AI Reshaping the Field of Sports Medicine. New Asian J Med. 2023;1(1):30–4. Available from: https://doi.org/10.61186/najm.1.1.30
5. Suo X, Tang W, Li Z. Motion Capture Technology in Sports Scenarios: A Survey. Sensors. 2024;24(9):2947. Available from: https://doi.org/10.3390/s24092947
6. Lapinski M, Paradiso JA, Kepple T, Moxley Scarborough D, Gill TJ, Berkson E, Brum Medeiros C. A Wide-Range, Wireless Wearable Inertial Motion Sensing System for Capturing Fast Athletic Biomechanics in Overhead Pitching. Sensors. 2019;19(17):3637. Available from: https://doi.org/10.3390/s19173637
7. Derungs A, Amft O. Estimating wearable motion sensor performance from personal biomechanical models and sensor data synthesis. Sci Rep. 2020;10:11450. Available from: https://doi.org/10.1038/s41598-020-68225-6
8. Li RT, Sheehan J, Kling SR, Cupp SA, Voos JE, Salata MJ. Wearable Performance Devices in Sports Medicine. Sports Health. 2015;8(1):74–8. Available from: https://doi.org/10.1177/1941738115616917
9. Liu L, Zhang X. A Focused Review on the Flexible Wearable Sensors for Sports: From Kinematics to Physiologies. Micromachines. 2022;13(8):1356. Available from: https://doi.org/10.3390/mi13081356

10. Liu SQ, Zhu R, Li GZ, Zhang JC. A Wearable Flow-MIMU Device for Monitoring Human Dynamic Motion. IEEE Trans Neural Syst Rehabil Eng. 2020;28(3):637–45. Available from: https://doi.org/10.1109/tnsre.2020.2971762
11. Liu Z, Wang X. Action recognition for sports combined training based on wearable sensor technology and SVM prediction. Prev Med. 2023;173:107582. Available from: https://doi.org/10.1016/j.ypmed.2023.107582
12. Rana M, Mittal V. Wearable Sensors for Real-Time Kinematics Analysis in Sports: A Review. IEEE Sens J. 2020;21(2):1187–207. Available from: https://doi.org/10.1109/jsen.2020.3019016
13. Seçkin AÇ, Seçkin M, Ateş B. Review on Wearable Technology in Sports: Concepts, Challenges and Opportunities. Appl Sci. 2023;13(18):10399.
14. Seshadri DR, Voos JE, Geletka BJ, Phelan DM, Hsu JJ, Gabbett TJ, Thom ML, Harlow ER, Drummond CK. Wearable Technology and Analytics as a Complementary Toolkit to Optimize Workload and to Reduce Injury Burden. Front Sports Act Living. 2021;2. Available from: https://doi.org/10.3389/fspor.2020.630576
15. Srivastava R, Mishra G, Sinha P, Patwari A, Kumar S, Kaligounder L. Efficient characterization of tennis shots and game analysis using wearable sensors data. IEEE. 2015. Available from: https://doi.org/10.1109/icsens.2015.7370311
16. Sun F, Zhu Y, Jia C, Zhao T, Chu L, Mao Y. Advances in self-powered sports monitoring sensors based on triboelectric nanogenerators. J Energy Chem. 2023;79:477–88. Available from: https://doi.org/10.1016/j.jechem.2022.12.024
17. Taborri J, Umek A, Keogh J, Kos A, Rossi S, Van Der Kruk E, Santuz A, Urbanczyk C. Sport Biomechanics Applications Using Inertial, Force, and EMG Sensors: A Literature Overview. Appl Bionics Biomech. 2020;2020(1):1–18. Available from: https://doi.org/10.1155/2020/2041549
18. Wagner JF. About Motion Measurement in Sports Based on Gyroscopes and Accelerometers—an Engineering Point of View. Gyroscopy Navig. 2018;9(1):1–18. Available from: https://doi.org/10.1134/s2075108718010091
19. Zaitsev D, Shabalina A, Egor E. High resolution miniature MET sensors for healthcare and sport applications. IEEE. 2018. Available from: https://doi.org/10.1109/icsenst.2018.8603579
20. Derungs A, Amft O. Estimating wearable motion sensor performance from personal biomechanical models and sensor data synthesis. Sci Rep. 2020;10(1). Available from: https://doi.org/10.1038/s41598-020-68225-6