Volleyball's Future: Integrating AI & Wearables in Training

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ABSTRACT

This review focuses on how AI and wearables revolutionize the training of volleyball players to enhance their performance and avoid injuries. This study aims to review the literature on AI and wearable technologies, examine their applications and developments, and discuss their advantages and disadvantages, leading to conclusions about future research and implementation needs. Core topics include wearable technologies that gather physiological and biomechanical markers (jump height, workload, sprint speed), machine-learning analytics for performance prediction and in-hone feedback, and the application of virtual reality (VR) for immersive training contexts.

Key insights emphasize that devices collecting data (for example IMUs, VERT) can best inform personalized training regimens. In contrast, predictive analytical tools enabled by AI can be used to improve decision-making and combat injury development. Reported gainful results, in NCAA volleyball systems and European federations, show quantifiable performance and injury prevention gains—reportable to the media—attributable to actual training time in these programs. Yet issues like data privacy concerns, the limitations of sensor accuracy, high expense, and reliance on AI instead of regular training coaches remain. AI and wearable technology are the keys to the advancement of volleyball training. Further research in sensors, ethical management of data, generalisability of AI models, and immersive VR systems may help make training efficient while ensuring the well-being of the athlete.

Keywords : AI; Wearable Technology; AI-Powered Analytics And Real-Time Feedback; Virtual Reality (VR).

I Introduction

Over the past few years, from training to performance to recovery, technology has integrated itself into sports and revolutionized many aspects of it. Wearable technology, artificial intelligence (AI), and data analytics and its amalgam offer new paradigms for sports training; (Biologics Coach Revolutionising Team Sport Training, n.d.). Thereby giving rise to a technological revolution that significantly improved performance metrics, reduced injury risks, and optimized training protocols in a wide range of sports disciplines. As the sport progresses into the 21st century, Volleyball is set to gain considerable benefits from technological forces of change as it evolves from its original form: dynamic rallies in an intense team environment (Javelin Sports, n.d.). Using advanced systems artificial intelligence and wearable devices you can easily integrate volleyball training and reshape the future of volleyball sport this paper provides an advanced paper on the future of volleyball training.

The Revolutions of Technology in Training Sports

Sports is undergoing one of the most technologically disruptive eras in history, as has been the case in many industries, and traditional methods of training are progressively giving way to technology-driven techniques. The research world shows that training using technology significantly enhances cognitive skills, decision-making capability, and psychological aspects such as motivation and attention (Semantic Scholar, n.d.). Advancements in information technologies, such as big data, IoT, wearables, AR, and VR, have revolutionized athlete development in the digital era and introduced a paradigm shift in athlete training and management (Semantic Scholar, n.d.). Only a 20% difference will be achieved in training efficiency through a human-computer interaction in exercise training, according to studies, which indicate how much technology can change an athletic performance [4].

Noticing the Framework of Volleyball Training

Now the volleyball training is quite different from the traditional one we are used to. Traditionally, volleyball coaching was based largely on visual observation, manual recording of statistics, and generalized training routines. Modern volleyball training is now also driven towards technological solutions that provide more accurate performance evaluation and individual training methods. Playing with the help of IMUs, pressure-sensitive display floors, and machine learning techniques that automatically detect significant behaviors and provide timely feedback to players and coaches (Frontiers in Sports and Active Living, 2024). The development of these systems is a great step towards sensor systems-based Android volleyball training environments which will improve individual and team performance.

Need AI and Wearable technology Volleyball

The fast-paced, highly technical nature of volleyball presents unique challenges that modern technology is well-placed to help solve. Wearable technology integrated with AI coaching provides an unprecedented arsenal for volleyball players and coaches alike (Move Sports, n.d.) Wearable technology can not only be used to optimize training but it can also be used for injury prevention. The use of these technologies allows for almost instantaneous feedback, providing insights into performance and physiological state that can be used to adjust the intensity or technique of the training program in real-time. Additionally, AI algorithms can process information from several data points, allowing for a more comprehensive insight into an individual's performance, health, and developments, and help enhance training plans through AS (Adaptive Sports) (Move Sports, n.d.).

The Effect AI and Wearables Have on Problem-Solving

AI and wearable technologies can solve some pain points in volleyball training. They beat the limits of human perception first, using precision beyond what can be seen with the naked eye to capture and quantify movements and physiological responses. Second, they allow objective measures of performance metrics, instead of relying on subjective assessments, but are based on data. Third, they enable individualized training protocols driven by athlete-specific data—not one-size-fits-all, but actual people. Fourth, they improve injury prevention by identifying fatigue or poor technique early on (Semantic Scholar, n.d.). Lastly, they enhance decision-making processes through game simulation and offer cognitive training through virtual environments (Semantic Scholar, n.d.).

II Research Objectives

The current study aims to investigate the AI and wearable technologies in volleyball training to cover the research gaps through three objectives:

- Review the literature on technology-enhanced volleyball training and summarise the current knowledge and research gap
- To review existing AI and wearable technologies used in volleyball, assessing their effectiveness, limitations, and barriers to their adoption
- Forecasting future trends based on technologies in volleyball training

Through achieving these aims, this study aims to add to the existing literature on technology-enhanced sports training and provide concrete, applicable takeaways for volleyball coaches, trainers, and athletes looking to implement these technologies in

pursuit of competitive advantage.

III Technology in volleyball: A review

Volleyball Training Using Wearable Technology

Wearable technologies are used in modern volleyball training:

- Jump analysis systems: For measurement of jump height, frequency, intensity, and landing impact, the VERT device offers NCAA Division II athletes detailed workload data relative to their position (Stanchfield & Vanguri, 2024).
- Inertial Measurement Units (IMUs): With pressure-sensitive floors can track player movement and detect specific actions with 78.71% accuracy using convolutional neural networks (Frontiers, 2024).
- Physiological monitors: Smart wristwatches collect cardiovascular and respiratory data, allowing you to predict performance through machine learning. Ozolcer et al. (2025)

Use cases AI in Sports Training

Action Identification and video processing

- Real-time wearable sensor-based automated volleyball video tagging using machine learning: 73.84% classification accuracy (Frontiers, 2024)
- Hybrid training systems: Incorporating computer vision and IMU data to form interactive feedback loops during drills (Postma et al., 2023)

Predictive Analytics

- Performance forecasting→ Hierarchical linear models from VERT data to predict position-specific jump volumes and intensities (Stanchfield & Vanguri, 2024)
- At present, AI is applied to talent identification: neural networks are used to analyze spatiotemporal patterns, ingrained in player profiles, in order to assess player potential (IEEE Pulse, 2024).

Automated Feedback Systems

- On-body biomechanical corrections in real-time while training (Frontiers, 2024)
- Cognitive training through simulated game scenarios Postma et al.

Experience and Evidence : Empirical Cases

A study (n=NCAA Division II athletes) on VERT over the course of a season showed:

- Outside hitter's experience impact forces 23% higher than setters
- Workload data are specific to position, allowing conditioning programs to be tailored (Stanchfield & Vanguri, 2024)
- National Volleyball Training Centre in China: PVDF-based sensors give instant biomechanical feedback while practicing spikes, with skill development accelerated by 37% on average compared to conventional coaching (VolleyCountry. com, 2024). In contrast, sensor reliability in variable environmental conditions increases challenge.

Project of smart Sports Exercises

European initiatives showed:

- Sensor-driven feedback, resulting in 19% more training efficiency
- 15% reduction in RSIs through movement pattern analysis (Postma et al., 2023)

Advances in predictive Modeling

A machine learning analysis of pre-season smartwatch data.

- Oxygen saturation (SpO2) variability as a key performance predictor (β=-0.430)
- Forecast hitting percentages for the season with 75% accuracy (Ozolcer et al., 2025)

IV. There are advantages and disadvantages to the use of AI and Wearable Technology in Volleyball.

Benefits

- **Data-Driven Decision-Making**

Edge with AI and wearable technologies, Coaches can access detailed and actionable insights based on real-time data. The VERT system and various devices actively assess jump height (height), landing impact forces (strength), and workload distribution (volume), allowing coaches to design individual-specific training programs incorporating external workload programs within player needs (De Bleecker et al., 2024). In one case, NCAA Division II volleyball teams implemented data collected through VERT to provide optimal plyometric regimens for their athletes, resulting in

a 60% reduction in injury rates when compared to the average practices (Stanchfield & Vanguri, 2024).

- **Real-Time Injury Prevention**

AI algorithms collated with wearables can monitor fatigue patterns and improper body mechanics. Kinexon IMU devices, for instance, track accumulated acceleration load (AAL) to detect overtraining possibilities while practicing high-intensity drills (Semantics Scholar, 2024). Machine learning players with real-time data on feedback mechanisms also lead to instant corrections when a player engages in movements deemed risky like improper jump landings (PubMed, 2024).

- **Customised workout plans**

Wearable devices collect physiological and biomechanical data, allowing AI-driven analytics to prescribe personalized training protocols. Smartwatches featuring heart rate monitors and oxygen saturation sensors enable predictive models to project the performance of a player over the course of a season (Ozolcer et al., 2025). This personalization allows them to train at their optimal intensities while greatly reducing the chances of being burned out or injured.

- **Enhanced Scouting & Recruitment**

AI systems analyze player movement patterns and their game statistics to discover the talent better. Longitudinal Spatiotemporal data of players can be utilized in modeling neural networks to analyze player potential based on metrics like spike velocity and court positioning efficiency (IEEE Pulse, 2024). Thus, professional leagues are utilizing these technologies to make recruitment processes more efficient, ensuring scouts are only spotting the most performance-worthy athletes.

Challenges

- **Data Privacy Concerns**

As a result, such collection of sensitive biometric data creates ethical concerns about privacy and security. Wearable devices frequently dominate the cloud-based platforms they send data to for analysis, leaving them susceptible to breaches. Research indicates a demand for strong encryption protocols and adherence to data protection laws such as GDPR (Semantics Scholar,2024). And note that without adequate safeguards, athletes may resist the adoption of these technologies over the fear of having their private information used against them.

- **Cost of Technology**

Furthermore, the high cost that comes with some of these AI-powered wearables limits their reach, especially for amateur teams and developing countries. Nonprofessional teams simply cannot afford devices such as Kinexon IMUs or higher-end smartwatches (Folio3. ai Blog, 2025). In addition to this, keeping these systems running requires investment in software updates and technical support, increasing operating costs even more.

- **Guidance as a Crutch vs. Coaching**

Traditional methods of coaching that rely on intuition and human judgment could be compromised by over-dependence on AI systems. Coaches could rely too much on the recommendations of the algorithm machines and will never be able to quantify contextual factors (Semantics Scholar, 2024). Solutions have emerged by combining the power of AI and the critical thinking of professionals.

- **Accuracy of the AI Models and Sensors**

AI algorithms and wearable sensors may show a range of reliability, which can depend on the type and quality of the devices used and the environmental conditions. Studies validating the VERT system reported proportional bias for impact force measurements when compared to force plate data (De Bleecker et al., 2024) for example. Likewise, machine learning-based models trained on small data sets might not be able to generalize across different player populations and match conditions. Resolution of these accuracy issues will require continued validation studies of sensor systems as well as iterative improvements in sensor technology.

V. Conclusion: The Role of AI and Wearable Tech in the Future of Volleyball Training

- **Improvements in AI performance analysis**

Performance enrichment: Machine learning is continuously improving its ability to analyze player performance. As IoT, IoMT devices, and wearables are used, the available data makes predictive analytics more accurate. Data-driven approaches, such as convolutional neural networks (CNNs) and recurrent neural networks (RNNs) are already being used for biomechanical data analysis to predict fatigue or injury risks (De Bleecker et al., 2024). These future AI systems should combine the latest in explainable AI, thus making complex yet amazing data outputs easy for coaches to digest. In an even recent study (Salim et al., 2024), such an automated AI video-tagging system also identify volleyball-specific actions (receiving, attacking, serving, etc.) and reports the results with high accuracy and precision for real-time feedback

during matches and training.

- **Wearable sensors**

As wearable technology progresses, it's likely to move toward non-intrusive designs that prioritize comfort and accuracy. Novel microfluidic sensors integrated into garments or skin patches are capable of continuously measuring biofluids, including sweat and interstitial fluid, allowing for the detection of hydration status, electrolyte balance, and stress levels (PubMed, 2024). Smart fabrics with integrated IMUs could promote a replacement of prevalent bulky devices and allow a lightweight, high-fidelity data collection embedded in the gameplay experience. It all allows athletes to get on with performing without carrying cumbersome hardware, with trainers and coaches privy to detailed physiological and biomechanical data during the workout.

- **Unified Architecture for Virtual Reality (VR) and AI**

AI and VR together will be transforming the training of volleyball sports through creating immersive simulations of game moments. VR exercises can recreate different match conditions and help with decision-making, positioning, and coordination. For example, setters could practice against virtual spikers in environments that replicate pressure situations, helping them better acclimate to adapting during real-life matches (VolleyCountry. com, 2024). Through AI algorithms as part of VR systems, player responses to these simulations can be gauged, thus delivering bespoke feedback to enhance skills development.

- **AI Coaching Assistants**

AI-based coaching assistants are an application of the future. These systems might create personalized training plans using individual performance metrics from wearables. AI assistants could recommend specific drills for improving weaknesses or optimizing strengths by analyzing data trends over time. These tools will support human coaches by automating repetitive tasks, such as monitoring workloads, allowing humans to put more effort into strategic training elements (Semantics Scholar, 2024).

VI. Future Research Directions

There are several areas worth exploring in more detail to unlock the potential of these technologies:

- • Exploring Ethical Uses of Data: Research on encrypted data-sharing protocols (like blockchain technology) will be crucial for developing privacy-by-design wearable devices.

- Sensor Accuracy: New wearable sensors need to be validated against gold-standard measurement tools in the target population to ensure robustness across different player populations.
- AI model generalization: Future-oriented datasets should include players across different demographics and skill levels to broaden the applicability of predictive models.
- Training with immersive systems: The next challenge would be to study the long-term effects of VR training on cognitive abilities and decision-making within the volleyball context.
- Generalization of AI Models: Widening the datasets from specific player segments to holistic player demographics to improve predictive analytics.

VII. Conclusion

From that point into the next ten years volleyball training will probably be completely combined with smart technologies providing ongoing observation as well as comments. Wearable sensors will become, but powerful, tools embedded into uniforms or skin patches. You'll be able to predict outcomes like never before with AI systems analyzing performance. Immersive VR environments will be a staple in the learning process for acquiring new skills, combining the best of constructing a body approach with constructing a mind approach. These trends will combine to offer a 360-degree view of athlete development — ensuring the athlete is performance-ready, as well as injury-free in the first place.

The use of these technologies along with their advanced algorithms make volleyball training more holistic and effective. Wearable sensors will be built directly into uniforms or equipment to allow ongoing surveillance without interrupting the competition. More advanced and refined predictive models will enable AI systems to further improve predictions around performance outcomes and risks of injury. VR facilities will imitate gameplay situations like never before and will allow players to make decisions with limited external influence. All these features come together to enable athletes to perform at their best while putting safety and well-being first.

AI and wearable technology are not just an augmentation of the volleyball training process but a crucial part of its future. The technologies will help reshape the landscape of the sport for both the players and coaches alike by addressing current issues through innovative research and ethical practices.

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