

(Table 3) contd....

Type of Simulation	Study	Benefits	Challenges
Screen-based Simulation	[43]	Promoted football talent identification and selection processes	Null
	[8]	Easily used through a computer	Null
	[44]	Null	Null
	[45]	Supplement to regular football training	The long-term effects are not clear
	[41]	Null	It failed to preserve the functional coupling between perception and action, lack of real-world application
	[42]	Null	It did not reproduce a player's first-person viewing perspective
	[46]	Without time and space constraints, low training risk	Null

3.3. What were the Benefits and Challenges of Simulation Technology in Football Training?

By summarizing the benefits of simulation technology (Table 3), we found the following benefits for the players: it provided immersive training in a fully virtual environment with no time and space constraints and low training risk [30, 34, 46], it allowed injured players to maintain a level of perceptual-cognitive skill [37], and it was easy to use through a computer [8]. Following are the benefits for coaches: it provides an additional instrument for player scouting and development improvement, promoting talent discovery and selection in football [31, 43]. Moreover, it was a supplement to regular football training [45].

By summarizing the challenges of simulation technology, we found that the long-term effects of training were not clear [40, 45]. The current results were not replicated in a verified real-world environment, as they did not reflect the real training and competitive environment [32, 35]. During body rotation or movement, participants worried that the hardware (cable) affected them [39]. It did not accurately reproduce a first-person perspective [42]. Moreover, there was a lack of theoretical and empirical justification for the included training tasks [30].

4. DISCUSSION

We reviewed 18 empirical studies on simulation technology in football training since 2014 and summarized the characteristics of simulation technology, the process of empirical research, and the benefits and challenges of simulation technology applied in football training. Next, we discussed the application of simulation technology in football training and the limitations and challenges of simulation technology.

4.1. Discuss the Application of Simulation Technology in Football Training

We summarized the following perspectives on the application of simulation technology in football training. The most significant benefits are its ability to generate realistic game scenarios and replicate match conditions, training, and testing in this virtual environment, which brings new training methods to coaches and athletes as a supplement to traditional training. The current studies reported that it allows players to work on specific technical skills in a focused and repetitive manner, and the instant feedback provided by the simulation software

allows players to discover areas for improvement and make adjustments that are needed to improve their abilities. Injury prevention and rehabilitation can also benefit from simulation technology. Players can simulate game movements and practice techniques using VR headset displays and motion-capture systems without putting undue strain on their bodies, creating a safer training environment and lowering the risk of injury. Furthermore, simulation technology created scenarios that challenged players to analyze game dynamics, anticipate opponents' moves, and make appropriate decisions. This helps enhance the players' tactical acumen and ability to adapt to different game situations, which challenges their mental abilities, such as perception, attention, and memory, ultimately improving their ability to process information and make quick decisions on the field. Finally, the interactive nature of simulation technology can increase engagement and motivation among football players and the realistic visuals and game-like experience of simulation training can make training sessions more enjoyable and engaging, leading to improved focus and effort from the players.

There has been some discussion about the use of simulation technology in football training in other studies. The VR platform has the potential to be used during the rehabilitation of injured football players who need to maintain a level of perceptual-cognitive skill while avoiding the physical stress experienced in real environments. VR has been shown to increase enjoyment, adherence to rehabilitation exercises, and confidence [47]. A VR digital gaming platform for teaching football skills might be useful during the rehabilitation of injured football players who need to keep their perceptual-cognitive skills while avoiding physical exercise [37]. Virtual technologies may be used to simulate real-life sporting environments, allowing players to play without worry of hurting themselves, recognize the details of each technical behavior, and examine their movements for miniature errors [48]. The advantage of using virtual reality to instruct sports skills is that it gives the user a sense of involvement and is an effective eye-hand coordination training solution that combines perception and action. VR offers an appealing option for a better understanding of the athlete perception-action process [49]. It allows players to practice decision-making in a controlled environment, which improves their understanding of tactical situations and the ability to make quick and effective decisions on the field. It indicates that

simulation technology can help football players develop tactical awareness and decision-making skills [27]. Sports video games can be an effective tool for motivating young individuals to engage in real-life sports and physical activity since they have a significant impact on cognitive engagement, affective engagement, behavioral engagement, and accessibility, all of which are strongly linked to real-life sports participation [50].

4.2. Limitations and Challenges of Simulation Technology in Football Training

While simulation technology has been shown to be beneficial in football training, it is not without limitations and challenges. These elements must be taken into account to ensure effective implementation and maximize the potential impact.

Simulation technology allows players to practice technical aspects, such as heading, shooting, and tactics, but it cannot simulate the physical demands and challenges of real-world match scenarios. Football is a contact sport, in which players must show skills while under pressure from opposing players, making it difficult to fully simulate these aspects in a virtual setting. Even if players excel in simulated training, it is unclear how well those skills translate to real-world scenarios. Transferring skills learned in a controlled virtual environment to actual matches can be ineffective because it does not accurately reflect the real training and competitive environment [32]. Even without pressure from the opposing player, simulating the demonstration of a skill or decision while running or jumping is rare in existing research. Therefore, the practice in the virtual environment is not very helpful to professional athletes at present. This is a direction worth studying in the future, and the training environment that combines virtual and reality may better meet the training requirements.

It cannot accurately replicate complex decision-making processes. In order to succeed in football, players must quickly assess a variety of options and react to changing circumstances. Even though they can present some decision-making difficulties, simulations frequently lack the spontaneity and unpredictability of actual match scenarios. This restriction might make it more difficult for players to adjust to a real game's dynamic nature. Additionally, it lacked practical application and failed to maintain the functional coupling between perception and action [41].

In terms of HMD, it is highly immersive VR. Due to the need for a lengthy cable trailing from the headset to transmit the visual data, HMDs have been claimed to disrupt a user's physical activities. Some are heavy and cumbersome, which may distract the user [51]. It was eventually overtaken by more user-friendly wireless VR headsets. Still, HMD users are unable to see their own hands, requiring the use of an avatar, which might lead to latency concerns [51]. Within such an environment, it is necessary to keep the athlete's constraints to a minimum and provide them the flexibility of movement they would enjoy in such situations. Despite all the advances in virtual

reality technology, for example, the reduction of latency in devices, such as HMDs, symptoms of cybersickness can still recur in a wide range of people. As a result, using VR for sports analysis and skill acquisition has its limitations, just like any other training method, and some aspects must be perceived or implemented in a real-world environment.

In terms of screen-based simulation, since it focuses primarily on visual and cognitive processing, it might not accurately mimic the physical demands and muscle memory formation needed in real-match scenarios. The development of motor skills and real-time physical feedback are not adequately addressed by video analysis despite its potential value for tactical learning and understanding of game patterns. Due to the simulator's low immersion level, screen-based simulations may cause attention problems and a lack of first-person perspective [42].

Many studies report difficulties related to exposure time in immersive simulation environments. Although there were no problems caused by prolonged exposure to simulators reported in the studies we selected, this is an aspect worth explanation and consideration. To solve the difficulties related to exposure time in an immersive simulation environment, it is necessary to consider optimizing hardware, control of exposure time, training user adaptability, and individual differences. This can improve the usability and user experience of simulation technology in football training.

4.2.1. Small Sample Size

This study faced limitations in terms of small samples or short study durations. For example, some studies used a relatively small number of participants, which could limit the generalizability of the findings. Additionally, due to the constraints of time and resources, some studies had a relatively short duration, which could limit the capture of long-term effects or fully assess the impact of simulation technology. These limitations highlight the need for future studies to include larger samples and longer durations to provide more robust and comprehensive evidence of the simulation's effectiveness. Simulation techniques are also highly specialized in differentiating players' skill levels, cognition, and decision-making abilities.

4.2.2. Usability

When studying usability involving users, it is necessary to focus on the diversity of users, including different ages, genders, skill levels, and backgrounds. At the same time, it is necessary to develop scientific test plans and methods to ensure the accuracy and reliability of test results. Through usability studies, the effectiveness, safety and usability of virtual simulation technology can be evaluated, and a reference can be provided for further promotion and application.

4.2.3. Youth vs. Professional Players

A limitation of the study was the disregarding of empirical studies on usability, especially on football

athletes. This paper contributes little to the training and improvement of professional players but is useful for identifying talented professional players for a team [31, 43]. Tests involving users can also bring important contributions related to the benefits and challenges of technology for football athletes. Future research could translate the success of amateur and young players into professional players, such as decision-making development.

5. FUTURE RESEARCH DIRECTIONS AND RECOMMENDATIONS

It is necessary to take into account the content validity and construct of the VR environment; this suggests that in order to give an in-depth comparison between the effectiveness of conventional training and VR training, the transfer of instructed skills must be assessed and confirmed by effectiveness under real-life situations [52]. It is crucial to assess how effectively training transfers from a simulated environment to a real environment. It is obvious that, in spite of the rapid development of VR sports platforms, the assessment of these simulators was left behind. The effectiveness of sport-related VR training should be extensively investigated before it can be implemented as a realistic and productive supplement to traditional sports training. Greater cooperation is required between those who develop these technologies and those who have the expertise and abilities to independently and deeply test and validate them. Another consideration is the effect on player interaction and team dynamics. Football is a fast-paced sport that requires communication and teamwork. Due to the use of simulation technology, the emphasis may shift toward individual training, limiting real-time interactions between players. Future research must strike the right balance between individual skill development and team collaboration for successful implementation.

More studies are needed to investigate the universality of impacts with simulation technologies. In addition to professional athletes and elite youth athletes, studies should include more diverse populations, children, students, and football novices. There is a need to focus on campus football and amateur football outside the professional football system to promote the popularization of simulation technology in football training. In professional football, there is a need to develop a design that combines simulation technology with training courses to verify the training effect through long-term training.

The nature of computer-based interactions is growing more diversified, with more overlap between various types of technologies and their applications. However, the integration of real-world and virtual environmental elements in sports applications has yet to be extensively studied. Firstly, the integration of VR and AR can enhance tactical training by creating more dynamic and interactive scenarios. VR technology can be used to recreate realistic game situations, allowing players to fully immerse themselves in a virtual football match. AR can then overlay additional information, such as tactical instructions, player

movement analysis, or real-time feedback, directly onto the player's field of view. This enables players to make tactical decisions in a realistic environment while having access to crucial information for optimal performance. Exploring the effectiveness of VR-AR integration, or 'mixed reality', in tactical training would be a promising direction.

CONCLUSION

This systematic review highlights the positive effects of simulation technology in improving technical skills, tactical decision-making, and injury prevention. There are three types of tools for applying simulation technology to football training, which significantly improves performance. These tools can be used as a supplement to regular football training. The HMD (immersive VR tool) is mainly used to train players in basic skills, with virtual reality headsets combined with IMU, making a motion tracking system for real-time feedback on user participation to achieve interaction. CAVE and screen-based simulations are mainly used to train and diagnose players' perceptual cognition and decision-making. CAVE interacts with the system through sensing equipment. Screen-based simulation interacts with the screen by using the mouse or key senses.

In conclusion, simulation technology has extensive applications in football training, effectively facilitating tactical training, injury prevention, rehabilitation, and skill development. However, the current limitations and challenges associated with simulation technology must be addressed. Future research should focus on overcoming these limitations to fully unlock the potential benefits of simulation technology in the football domain. With continued advances and research, a balanced approach that combines simulation training with real on-field practice, tactical training and match experience is essential for players to develop a well-rounded ability. Exploring the training environment, combining VR and AR, and promoting a better combination of simulation training and reality is the future development trend.

LIST OF ABBREVIATIONS

VBT	=	Video-based Training
CAVE	=	Cave Automatic Virtual Environment
VR	=	Virtual Reality

CONSENT FOR PUBLICATION

Not applicable.

STANDARDS OF REPORTING

PRISMA guidelines and methodology were followed.

AVAILABILITY OF DATA AND MATERIALS

The data that supporting the findings of this study will be available from corresponding author [J.S.] upon request.

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CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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SUPPLEMENTARY MATERIAL

PRISMA checklist is available as supplementary material on the publisher's website along with the published article.

Supplementary material is available on the publisher's website along with the published article.

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