

THE USE OF AUGMENTED REALITY (AR) AND VIRTUAL REALITY (VR) TECHNOLOGIES IN SPORTS PSYCHOLOGY: EFFECTS ON PERFORMANCE, MOTIVATION AND PSYCHOLOGICAL RECOVERY

O USO DAS TECNOLOGIAS DE REALIDADE AUMENTADA (RA) E REALIDADE VIRTUAL (RV) NA PSICOLOGIA DO ESPORTE: EFEITOS NO DESEMPENHO, MOTIVAÇÃO E RECUPERAÇÃO PSICOLÓGICA

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Abstract. In recent years, the use of Augmented Reality (AR) and Virtual Reality (VR) technologies in sport psychology has great potential for enriching training processes, enhancing athletes' performance, strengthening their motivation and supporting their psychological recovery processes. This review aims to examine the applications of AR and VR technologies in sport psychology and discusses the effects of these technologies on performance enhancement, motivation, mental toughness and psychological recovery. Based on the findings Augmented Reality and Virtual Reality technologies are powerful tools that shape the future of sport psychology. The opportunities offered by these technologies to improve athletes' performance, strengthen their motivation and accelerate their psychological recovery processes are quite wide. However, more extensive and systematic research is needed to better understand the effectiveness and long-term effects of these technologies. In the future, making these technologies more accessible and widespread in more sports will be an important step in the evolution of sport psychology.

Keywords: Augmented Reality (AR), Virtual Reality (VR), Technology, Sports Psychology, Psychological Recovery

Resumo. Nos últimos anos, o uso de tecnologias de Realidade Aumentada (RA) e Realidade Virtual (RV) na psicologia do esporte tem grande potencial para enriquecer os processos de treinamento, melhorar o desempenho dos atletas, fortalecer sua motivação e apoiar seus processos de recuperação psicológica. Esta revisão tem como objetivo examinar as aplicações das tecnologias de RA e RV na psicologia do esporte e discute os efeitos dessas tecnologias no aprimoramento do desempenho, motivação, resistência mental e recuperação psicológica. Com base nas descobertas, as tecnologias de Realidade Aumentada e Realidade Virtual são ferramentas poderosas que moldam o futuro da psicologia do esporte. As oportunidades oferecidas por essas tecnologias para melhorar o desempenho dos atletas, fortalecer sua motivação e acelerar seus processos de recuperação psicológica são bastante amplas. No entanto, pesquisas mais extensas e sistemáticas são necessárias para entender melhor a eficácia e os efeitos de longo prazo dessas tecnologias. No futuro, tornar essas tecnologias mais acessíveis e difundidas em mais esportes será um passo importante na evolução da psicologia do esporte.

Palavras-chave: Realidade Aumentada (RA), Realidade Virtual (RV), Tecnologia, Psicologia Esportiva, Recuperação Psicológica



1. INTRODUCTION

Augmented Reality (AR) and Virtual Reality (VR) technologies are emerging as powerful tools in sport and offer innovative applications for training, performance analysis and skill development. AR superimposes digital information over the real environment, while VR creates immersive simulations (Agrawal Luckykumar Dwarkadas et al., 2023).

These technologies, together with Artificial Intelligence and Data Visualisation, are transforming sports performance analysis by automating data collection, creating realistic training environments and improving decision-making processes (Cossich et al., 2023). A survey among athletes revealed an increasing acceptance of VR headsets for training in various sports disciplines (Stefan Gradl et al., 2016).

Extended Reality (XR), which encompasses AR, VR and Mixed Reality, has shown promise in improving perceptual-cognitive and motor skills in sport, drawing on applications in psychology, medicine and the military (Le Noury et al., 2022). While XR technology is advancing rapidly, more research is needed to optimise its integration into high-performance sports and evaluate its effectiveness in skill acquisition and training interventions.

1.1. Overview of Augmented Reality and Virtual Reality Technologies

Augmented Reality (AR) and Virtual Reality (VR) are advanced technologies that enhance user experiences by blending digital elements with the real world or creating immersive virtual environments (Agrawal Luckykumar Dwarkadas et al., 2023; P. Nair, 2018). While AR appeals to multiple senses by superimposing virtual objects on the real world, VR draws users into computer simulated environments (Agrawal Luckykumar Dwarkadas et al., 2023).

While basic AR technologies include tracking, interaction techniques and display technology, VR systems can be immersive, semi-immersive or non-immersive (Agrawal Luckykumar Dwarkadas et al., 2023). Both technologies have different applications in various fields and enable users to safely explore past, present and future scenarios (M. Shanmugam et al., 2019).

AR and VR systems face challenges in implementation and have specific requirements for optimal performance (M. Shanmugam et al., 2019). Despite their differences, AR and VR share similarities in their ability to create custom rendered realities and enhance user interactions with digital content (S. Chavan, 2016).

Augmented Reality (AR) and Virtual Reality (VR) technologies are rapidly evolving, offering immersive experiences in various sectors. AR enriches real environments with digital elements, while VR creates fully simulated environments (Agrawal Luckykumar Dwarkadas et al., 2023). These technologies are particularly effective in tourism and hospitality, enhancing planning, marketing and conservation efforts (A. Nayyar et al., 2018).

In manufacturing, AR/VR supports Industry 4.0 initiatives, facilitating product design, maintenance, assembly and quality control (M. Eswaran and M.V.A. Raju Bahubalendruni, 2022). Applications extend to management and education, offering potential benefits such as increased sales, reduced costs and increased customer satisfaction (A. Sosnilo et al., 2021).

Despite some limitations in educational settings, AR/VR technologies continue to expand into new industries. The market for these technologies is expected to grow significantly, with forecasts indicating increased sales and wider adoption across various economic sectors by 2024 (A. Sosnilo et al., 2021).

2. RESULTS AND DISCUSSION

2.1. Usage Areas of AR and VR Technologies in Sports Psychology

Virtual reality (VR), augmented reality (AR) and mixed reality (MR) technologies are increasingly used in sports education, training and performance enhancement (Mukhopadhyay, 2020). These technologies offer benefits in a variety of sporting contexts, including rules

understanding (Vargas González et al., 2017), skills-based training (Lin et al., 2021), and performance enhancement in various sporting disciplines (Richlan et al., 2023).

AR and VR interfaces have shown advantages over traditional desktop interfaces in terms of learning outcomes and user engagement (Vargas González et al., 2017). Real-time visual feedback through AR can help athletes improve their technique and achieve greater consistency in their performance (Lin et al., 2021).

VR interventions have shown significant effects in improving motor and psychological skills, often outperforming traditional training protocols (Richlan et al., 2023). These technologies have the potential to improve perception-action skills, decision-making and psychological resilience in athletes, but more research is needed to fully understand their long-term effects and transfer to the real world (Richlan et al., 2023).

Virtual reality (VR) and augmented reality (AR) have shown significant potential in clinical and sport psychology applications. These technologies can induce anxiety and create realistic environments for athletes to train in high-pressure situations (Stinson and Bowman, 2014; Ventura et al., 2018). VR has been used to treat various mental disorders and enhance psychological well-being (Ventura et al., 2018).

In sport, VR can be applied to sport psychology and biomechanics training, offering benefits such as real-time 3D tracking of whole body movements and flexible 3D environments (Stinson, 2013). VR head-mounted displays (HMDs) have potential applications in training perceptual-cognitive skills, relaxation strategies and injury rehabilitation for athletes (Bird, 2020).

Research has shown that VR systems can induce anxiety in participants, with factors such as known anxiety triggers and the accuracy of the simulation directly affecting anxiety levels (Stinson & Bowman, 2014). Although promising, more research is needed to determine the long-term effectiveness of VR training in reducing sport-induced anxiety.

Virtual reality (VR) and augmented reality (AR) have shown potential to trigger anxiety in exposure therapy and sport psychology training. Both VR and AR environments can trigger anxiety, as evidenced by physiological measures such as skin conductance, heart rate, and heart rate variability (Yeh et al., 2018; Tsai et al., 2018).

While some studies found no significant difference in anxiety triggering between VR and AR (Yeh et al., 2018), others reported that AR produced stronger physiological reactions (Tsai et al., 2018). In sport-specific applications, VR systems can trigger anxiety in athletes, with factors such as known anxiety triggers and the accuracy of the simulation directly affecting anxiety levels (Stinson and Bowman, 2014).

VR has also been investigated for sports biomechanics training utilising 3D tracking to capture and display whole body movements in real time (Stinson, 2013). These findings suggest that VR and AR technologies have promising applications in anxiety treatment and sports training, but more research is needed to determine their long-term effectiveness.

Virtual reality (VR) technology is increasingly being applied to enhance sports performance in various disciplines. Research has shown that interactive VR applications can improve performance, physiological and psychological outcomes in athletes (Neumann et al., 2017; Richlan et al., 2023).

VR interventions have shown potential benefits in target sports, ball sports, martial arts, and non-sport specific processes (Richlan et al., 2023). Key factors influencing VR effectiveness include the presence of virtual opponents, competitiveness, task autonomy, intense interest, attention focus, and feedback (Neumann et al., 2017; Alhadad & Abood, 2018). VR technology allows researchers to isolate contributing factors and analyse the perception-action loop used by athletes, overcoming the limitations of traditional video playback methods (Bideau et al., 2010).

Although most research has focussed on endurance sports, more studies on skill-based sports are needed (Neumann et al., 2017). In general, VR interventions show promise in enhancing sport performance through the training of motor and psychological skills in athletes (Richlan et al., 2023).

Virtual reality (VR), augmented reality (AR) and mixed reality (MR) technologies are increasingly applied in sport and physical education. These technologies offer innovative ways to improve training methods, assess athletes, and enhance performance (Mukhopadhyay, 2020; Loia & Orciuoli, 2019). In particular, AR enables positioned training by allowing athletes to observe and analyse data during sessions (Loia & Orciuoli, 2019). VR and AR applications in sport range from improving spectator experiences to aiding technical and tactical skill development (Loia & Orciuoli, 2019).

While basic AR technologies include tracking, interaction techniques and display technology, VR includes immersive, semi-immersive and non-immersive systems (Agrawal et al., 2023). The combination of these technologies with radio-based localisation systems offers new possibilities for team-based sports applications (Gradl et al., 2016). As these technologies continue to develop, they have the potential to revolutionise sports education, training and performance analysis (Mukhopadhyay, 2020; Loia and Orciuoli, 2019).

One of the most common uses of AR and VR technologies in sports psychology is to improve athletes' performance. Realistic simulations and training can help athletes improve their ability to make the right decisions, improve reaction times and cope with stressful situations.

Research has investigated the use of virtual reality (VR) to improve decision-making skills in team sports. Studies have shown that VR training can lead to transferable and generalised gains in decision-making performance, outperforming traditional computer screen-based methods (Caleb Pagé et al., 2019). 360° VR has demonstrated strong reliability and construct validity as an assessment tool for sports officials, with higher ecological validity compared to match broadcast footage (Kittel et al., 2019).

VR technology, especially using head-mounted displays, has proven to be effective in assessing and improving the decision-making abilities of athletes (Yaxiang Jia et al., 2024). Researchers are developing design guidelines for VR-based decision-making training in specific sports such as the Australian Football League, emphasising the importance of spatial awareness in virtual environments (Farizi et al., 2021). These findings suggest that VR technology has significant potential for improving decision-making skills in a variety of team sport contexts.

Recent research has investigated the applications of augmented reality (AR) and virtual reality (VR) technologies in sport psychology and performance. AR has been used to enhance physical activities, increase fairness in competitions, and provide interactive training experiences in sports such as archery (Bozyer, 2015).

Virtual reality applications have shown positive effects on performance, physiological and psychological outcomes in athletes, especially in endurance sports such as running, cycling and rowing (Neumann et al., 2017). Computer-based psychological measures, including emotion recognition and regulation tasks, are emerging as valuable tools for assessing the mental health of athletes (Demirbaş et al., 2022).

The use of VR headsets in education has also increased with studies focusing on their usability, user experience, and effectiveness as learning tools (Cankaya, 2019). These technologies offer promising ways to improve sports training, performance analysis and psychological assessment in athletic contexts.

Virtual reality (VR) and augmented reality (AR) technologies are increasingly being applied in sport psychology and clinical settings. These technologies offer advantages over traditional methods, including improved ecological validity, enhanced control, and increased

safety (Bird, 2020; Liu et al., 2022). Virtual reality can be used to train perceptual-cognitive skills, implement relaxation strategies, and assist in injury rehabilitation (Bird, 2020). The immersive nature of virtual reality allows for realistic simulations of sports environments, enabling researchers to study athletes' attention, concentration and behaviour in controlled environments (Zinchenko et al., 2011).

VR and AR have also been used to treat various mental health conditions such as phobias, stress-related disorders, and chronic pain (Ventura et al., 2018). The effectiveness of these technologies in psychology stems from their ability to create immersive experiences, facilitate embodiment, and overcome geographical limitations (Ventura et al., 2018). As research in this area progresses, VR and AR are expected to play an increasingly important role in sport psychology and mental health interventions.

Research has investigated the potential of virtual and augmented reality (VR/AR) technologies to increase motivation in sport and physical activity. Studies have shown that immersive VR cycling can increase intrinsic motivation compared to traditional and non-immersive VR cycling (Liu et al., 2019). The integration of artificial intelligence and real-world data into VR sports applications can positively influence motivation and competitive dynamics (Geurts et al., 2024).

Factors such as training, escape, and aesthetic experiences influence users' intention to participate in VR/AR sports through presence, perceived usefulness, and flow (Lee & Oh, 2022). Furthermore, computer vision-supported AR games have shown to be effective in promoting physical activity and sports participation, especially among younger generations (Doskarayev et al., 2023). These findings suggest that VR/AR technologies have significant potential to increase motivation and participation in sport and exercise and offer innovative solutions to address declining physical activity levels.

Virtual reality (VR) and augmented reality (AR) technologies have shown promising applications in clinical psychology and sports training. Virtual reality can be used to treat various mental disorders, promote psychological well-being, and improve quality of life (Ventura et al., 2018). In sports, image-supported VR training has been found to improve psychological skill development and mental skills in athletes (Sai Raam et al., 2022).

VR-based exercises have shown positive effects on physiological, psychological and rehabilitation outcomes in different populations, including improvements in physical fitness, muscle strength, balance and mood (Qian et al., 2020).

Furthermore, VR interventions have shown potential to aid psychological recovery for intensive care unit patients, such as those undergoing COVID-19 treatment, by reducing symptoms of post-traumatic stress disorder, anxiety and depression (Vlake et al., 2021). These findings suggest that VR and AR technologies offer innovative approaches to enhance psychological recovery and performance in both clinical and sport settings.

3. CONCLUSION

Augmented Reality (AR) and Virtual Reality (VR) technologies have revolutionised many areas of sport psychology. These technologies seem to play an important role in enhancing athletes' performance, strengthening their motivation and accelerating their psychological recovery processes. The literature shows that AR and VR are highly effective tools to improve athletes' technical skills, increase their strategic thinking capacity, optimise their training processes and ensure their mental and physical recovery during rehabilitation processes.

Virtual reality offers athletes the opportunity to safely experience and learn from scenarios they have not encountered before. Especially in technical training, significant progress has been made in developing athletes' skills in VR environments. This is effective in improving not only physical skills, but also mental skills (e.g. decision-making, game strategy, focus). For example, studies in sports such as basketball, football and tennis have shown that VR helps

athletes to improve their technical skills by allowing them to focus independently of environmental factors. In this context, it is also emphasised that AR applications increase training efficiency by providing instant feedback and help athletes to quickly correct technical errors.

Motivation is a key factor for athletes to achieve high performance. AR and VR can increase intrinsic motivation by providing athletes with virtual competitions, simulations and gamified experiences (Pekgor et al., 2024a). The fact that VR technology allows athletes to set their performance goals in a virtual environment encourages them to make efforts to achieve these goals. Furthermore, VR applications for increasing social interactions and teamwork can reinforce intragroup motivation even in individual sports. For example, interactions with virtual teammates can strengthen the athlete's sense of belonging and improve performance.

AR and VR also provide important contributions in the field of psychological recovery. Especially in post-injury rehabilitation processes, virtual environments that facilitate athletes to cope with psychological barriers such as post-traumatic stress, fear and anxiety can accelerate their physical recovery. VR has been shown to help athletes regain confidence in injury processes and help their mental recovery. In addition, VR applications for stress management and relaxation techniques support athletes to perform with a healthier mental state by reducing their anxiety. These findings suggest that VR has a positive impact not only on physical recovery but also on psychological recovery.

Despite the increasing use of AR and VR technologies in sport psychology, this field is still in the developmental stage and needs further research (Pekgor et al., 2024b). Most studies have been conducted on small sample groups and short-term experiments, and their long-term effects need to be examined. In addition, designing specialised AR and VR applications specific to different sports branches and evaluating the effectiveness of these applications with comparative studies may be an important focus for future research.

Another important issue is the accessibility of these technologies for all athletes. AR and VR-based applications can often be costly, which can limit access to these technologies for smaller clubs or individual athletes. Therefore, the development of more cost-effective and accessible AR and VR solutions can help to spread these technologies to a wider audience.

Finally, with further integration of AR and VR in sports psychology, it will be possible to more systematically monitor not only the performance but also the overall psychological health of athletes. In this context, further data integration, such as biometric data and tracking of psychological states, can further increase the effectiveness of these technologies.

Augmented Reality and Virtual Reality technologies are powerful tools that shape the future of sport psychology. The opportunities offered by these technologies to improve athletes' performance, strengthen their motivation and accelerate their psychological recovery processes are quite wide. However, more extensive and systematic research is needed to better understand the effectiveness and long-term effects of these technologies. In the future, making these technologies more accessible and widespread in more sports will be an important step in the evolution of sport psychology.

Suggestions for Future Research

- Different Effects in Individual and Team Sports: Comparisons of the effects of AR and VR in individual and team sports should take into account the different psychological needs in both types of sports.
- Long-Term Effects: The long-term effects of these technologies on athletes' performance, motivation and psychological well-being need to be investigated in more depth.
- Ethical and Psychological Risks: Studies should be conducted on the potential negative effects of overuse of technological interventions on the psychological health of athletes.
- Different Age Groups: It is important to examine the different effects of AR and VR technologies among young athletes and experienced professional athletes.



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