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Virtual Reality Interventions for Anxiety Reduction and Performance Enhancement in Athletes: A Protocol for a Systematic Review and Meta-Analysis

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INTRODUCTION

*R*eview question / Objective 8.1Primary Question: What is the effectiveness of virtual reality interventions in reducing anxiety and enhancing performance in competitive athletes compared to traditional interventions or control conditions?
8.2Secondary Questions:i.How do virtual reality interventions compare to traditional anxiety management techniques in athletic populations?
ii.What virtual reality intervention characteristics (duration, frequency, type of VR system, immersion level) are most effective for anxiety reduction?
iii.Do virtual reality intervention effects vary by sport type, competitive level, athlete demographics, or anxiety severity?
iv.What are the sustained effects of virtual reality interventions on athlete performance outcomes?

Rationale Anxiety represents one of the most prevalent mental health concerns among competitive athletes, affecting approximately 35% of elite athletes and contributing to performance decrements, sport dropout, and reduced well-being (Reardon et al., 2019; Taylor et al., 2023). Among college athletes, anxiety affects a substantial proportion, yet only 10% of those with mental health conditions seek professional help (Sagar-Ouriaghli et al., 2020), highlighting the need for innovative, accessible intervention approaches that can overcome traditional barriers to mental health service utilization.

Virtual reality technology has emerged as a revolutionary tool in sports psychology applications, offering unique advantages including improved ecological validity, enhanced experimental control, reproducibility, and the ability to create safe, controlled environments for exposure-based interventions. VR technology provides multiperceptual, immersive, and interactive experiences that may enhance engagement and therapeutic outcomes compared to traditional anxiety management approaches (Liu

et al., 2022; Zhang et al., 2025). Recent advances in VR-based applications show potential for real-time biofeedback integration, offering more entertaining and adaptive feedback modalities that may enhance training performance and outcomes. The application of VR in sports psychology represents a rapidly evolving field with significant therapeutic potential. Modern technological advancements combine virtual reality with intelligent systems and neurofeedback capabilities, creating new opportunities for individualized and context-sensitive anxiety management support. Current trends show VR technology transforming sports psychology through real-time mental state monitoring, immersive simulation environments, and personalized intervention delivery that can be tailored to specific sport contexts and individual athlete needs.

Despite promising developments and growing adoption in clinical psychology, the effectiveness of VR interventions for anxiety management specifically in athletic populations remains insufficiently synthesized. While individual studies demonstrate potential benefits, no comprehensive systematic review has examined VR interventions specifically targeting sport-related anxiety across different athletic populations, intervention types, and outcome measures. This represents a critical knowledge gap as VR technology becomes increasingly accessible and cost-effective for sports organizations, and as the field moves toward evidence-based integration of technology-enhanced mental health interventions..

Condition being studied This review will examine anxiety disorders and anxiety-related performance issues in competitive athletes, specifically focusing on sport-related anxiety, performance anxiety, and general anxiety symptoms that impact athletic performance and well-being. The review will consider both clinical anxiety presentations and subclinical anxiety symptoms that interfere with optimal athletic functioning.

METHODS

Search strategy The following databases will be searched: PubMed/MEDLINE, Scopus, Web of Science, SPORTDiscus, and CINAHL.
Search terms will include combinations of: Virtual reality terms: "virtual reality", "VR", "immersive technology", "virtual environment", "computer simulation", "head-mounted display", "HMD"; Intervention terms: "intervention", "treatment", "therapy", "training", "program"; Anxiety terms: "anxiety", "stress", "performance anxiety", "sport anxiety", "competitive anxiety", "worry"; Population terms: "athletes", "sports", "athletic",

"competitive sport", "elite athletes", "student-athletes"; Outcome terms: "performance", "anxiety reduction", "stress management", "mental health"
The search strategy will be refined for each database to account for different controlled vocabularies and indexing systems. Reference lists of included studies and relevant systematic reviews will be hand-searched for additional eligible studies.

Participant or population Studies involving competitive athletes of any age, gender, or sport type will be considered. Competitive athletes are defined as individuals who participate in organized sport at regional, national, or international levels, including high school, collegiate, amateur, semi-professional, and professional athletes.
Exclusion criteria for participants: (1) recreational or casual sport participants without competitive involvement; (2) individuals with severe psychiatric disorders requiring intensive clinical intervention; (3) athletes with diagnosed neurological conditions that may confound VR intervention effects; (4) studies focusing exclusively on motor skill acquisition without anxiety-related outcomes.

Intervention The intervention will be virtual reality-based anxiety management programs defined as structured interventions utilizing immersive virtual reality technology (head-mounted displays or immersive projection systems) specifically designed to reduce anxiety or enhance performance in athletic contexts. Interventions may include VR exposure therapy, VR-enhanced relaxation training, VR-based mindfulness programs, VR simulation training, or VR-integrated biofeedback approaches.

Comparator Comparators will include traditional anxiety management interventions (cognitive-behavioral therapy, relaxation training, mindfulness-based interventions), placebo/sham VR conditions, waitlist controls, or standard care/no intervention groups.
13.3.Studies Design to be Included
Randomized controlled trials (RCTs), controlled clinical trials, and crossover studies will be included. Quasi-experimental studies with adequate control groups may be considered if they meet quality criteria.

Study designs to be included Randomized controlled trials (RCTs), controlled clinical trials, and crossover studies will be included. Quasi-experimental studies with adequate control groups may be considered if they meet quality criteria.

Eligibility criteria 16.1Inclusion criteria:

(1) RCTs, controlled clinical trials, or crossover studies; (2) competitive athletes as defined above; (3) VR-based anxiety management intervention; (4) comparison with control group or alternative intervention; (5) anxiety-related outcome measures (anxiety scales, stress biomarkers, performance under pressure); (6) articles published from January 1, 2016 to June 30, 2025; (7) English language publications; (8) peer-reviewed journal articles.
16.2Exclusion criteria:
(1) studies on non-competitive or recreational participants; (2) studies without control groups; (3) non-human studies; (4) conference abstracts, dissertations, or grey literature; (5) studies focusing solely on motor skill learning without anxiety outcomes; (6) case studies or case series; (7) studies using non-immersive VR systems (flat screens, tablets).

Information sources
The review will adhere to PRISMA 2020 guidelines for systematic reviews and meta-analyses. Electronic databases (PubMed/MEDLINE, Scopus, Web of Science, SPORTDiscus, CINAHL) will be systematically searched. Additional sources will include reference lists of included studies, relevant systematic reviews, and contact with study authors for unpublished data when necessary.

Main outcome(s)
18.Main Outcome(s):
18.1.Primary outcomes:
Anxiety levels: Measured by validated anxiety scales (e.g., Sport Anxiety Scale-2, Competitive State Anxiety Inventory-2, State-Trait Anxiety Inventory, Beck Anxiety Inventory)
Performance under pressure: Objective performance measures during anxiety-provoking conditions or competitive scenarios
Physiological anxiety indicators: Heart rate variability, cortisol levels, galvanic skin response, or other stress biomarkers
18.2.Hierarchy of outcome measures:
i.Sport-specific anxiety questionnaires
ii.General anxiety questionnaires
iii.Physiological stress indicators
iv.Performance measures during stressful conditions.

Additional outcome(s)
a)Athletic performance: Sport-specific performance measures, skill execution accuracy, reaction time
b)Self-efficacy and confidence: Sport confidence measures, self-efficacy scales
c)Intervention acceptability: User experience ratings, adherence rates, satisfaction scores

d)Psychological well-being: General mental health measures, mood scales, quality of life indicators
e)Long-term effects: Follow-up measures at various time points post-intervention
f)Adverse effects: VR-related side effects (cybersickness, disorientation), dropout rates.

Data management
Two independent reviewers will screen titles and abstracts based on inclusion criteria, followed by full-text screening by two independent reviewers. Disagreements will be resolved through discussion or consultation with a third reviewer. A standardized data extraction form will be developed and piloted before use. Data extraction will be performed independently by two reviewers, with discrepancies resolved through discussion.Two independent reviewers will screen titles and abstracts based on inclusion criteria, followed by full-text screening by two independent reviewers. Disagreements will be resolved through discussion or consultation with a third reviewer. A standardized data extraction form will be developed and piloted before use. Data extraction will be performed independently by two reviewers, with discrepancies resolved through discussion.

Quality assessment / Risk of bias analysis
The Cochrane Risk of Bias Tool 2.0 (RoB 2) will be used to assess risk of bias in randomized controlled trials. The GRADE (Grading of Recommendations Assessment, Development and Evaluation) approach will be employed for overall evidence quality assessment. Funnel plots and Egger's test will be used to assess publication bias when sufficient studies are available (≥10 studies).

Strategy of data synthesis
Statistical analysis will involve random-effects meta-analysis using the DerSimonian-Laird method. Standardized mean differences (SMD) with 95% confidence intervals will be calculated for continuous outcomes. Risk ratios will be computed for dichotomous outcomes. Heterogeneity will be assessed using the I^2 statistic and interpreted as: 75% (considerable). Meta-regression analyses will explore potential effect moderators when sufficient studies are available.

Subgroup analysis
Planned subgroup analyses will include:
a)VR intervention type: Exposure therapy, relaxation training, mindfulness, simulation training, biofeedback
b)Intervention duration: Short-term (8 weeks)
c)Athlete characteristics: Age groups, competitive level, sport type (individual vs. team sports)
d)Technology characteristics: Immersion level, VR system type, presence of biofeedback integration

e)Comparison type: Active controls vs. inactive controls

f)Baseline anxiety severity: High vs. low baseline anxiety levels.

Sensitivity analysis
Sensitivity analyses will assess the impact of:
a)Study quality (excluding high risk of bias studies)
b)Study design (parallel vs. crossover trials)
c)Intervention delivery (individual vs. group)
d)Statistical model choice (fixed-effects vs. random-effects)
e)Missing data handling methods
f)Publication type and funding source.

Language restriction Only studies published in English will be included.

Country(ies) involved China.

Other relevant information The protocol follows PRISMA-P 2020 guidelines for systematic review protocols. The review will be registered with INPLASY prior to commencement of data extraction.

Keywords Virtual Reality; Athletes; Anxiety; Sports Psychology; Performance Enhancement; Mental Health; Systematic Review; Meta-Analysis; Technology-Enhanced Interventions; Immersive Technology.

Dissemination plans Results will be published in a peer-reviewed sports psychology or sports medicine journal. Findings will be presented at relevant academic conferences and shared with sports psychology professional organizations. A summary of findings will be prepared for practitioners and sports organizations.

Contributions of each author
Author 1 - ZHANG ZITONG - Collected and reviewed the literature, organized and summarized the findings, drafted the manuscript, and revised the manuscript.
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