Harnessing VR extreme sports for mental health assessing stress excitement and anxiety modulation in men with social anxiety disorder

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Summary. Background. Men with social anxiety disorder face significant challenges in many aspects of daily life, and while pharmaceutical treatments are available, they often come with side effects. Additionally, some men are reluctant to undergo psychological treatment openly. This study aims to investigate the effects of virtual reality-based extreme sports games on stress, emotion, and anxiety levels in men with social anxiety disorder. **Methods**. Utilizing a quasi-experimental design with pre-test, post-test, and 30-day follow-up assessments, this study recruited 84 men diagnosed with Social Anxiety Disorder (SAD) via convenience sampling from psychology clinics and anxiety associations in Tehran, Iran. Participants were randomly allocated to either an experimental group (n=42) or a control group (n=42). The experimental intervention involved a series of immersive virtual reality (VR) simulations based on extreme sports, whereas the control condition participated in standard, non-VR physical exercise routines. To measure the primary outcomes, the validated Depression, Anxiety, and Stress Scale was administered at all three assessment points. Data analysis was performed using Analysis of Covariance (ANCOVA), controlling for baseline scores as covariates. Subsequently, Bonferroni-adjusted pairwise comparisons were conducted to scrutinize specific changes between the different time points. **Results**. The VR intervention produced significant reductions in depression (post-test partial $\eta^2 = .283$; follow-up $\eta^2 = .261$), anxiety (post-test $\eta^2 = .320$; follow-up $\eta^2 = .301$), and stress levels (post-test $\eta^2 = .341$; follow-up $\eta^2 = .327$; all $p < .001$). Pairwise comparisons confirmed robust decreases from baseline to post-test that were largely sustained at the 30-day follow-up. **Conclusions**. These findings suggest that virtual reality-based extreme sports games may serve as a safe, non-pharmaceutical intervention for men with this condition, paving the way for further extensive research in this area. The enhanced engagement in these digital platforms allowed subjects to confront their fears in a controlled space, thereby facilitating exposure therapy dynamics without the associated risks of actual extreme sports.

Key words. Men anxiety, extreme sports, men's mental health, virtual reality, ASD.

Uso degli sport estremi in realtà virtuale per la salute mentale: valutazione della modulazione di stress, eccitazione e ansia negli uomini con disturbo d'ansia sociale

Riassunto. Background. Gli uomini affetti da disturbo d'ansia sociale affrontano difficoltà significative in numerosi ambiti della vita quotidiana; sebbene siano disponibili trattamenti farmacologici, questi comportano spesso effetti collaterali. Inoltre, alcuni uomini mostrano riluttanza a intraprendere percorsi psicoterapeutici in modo esplicito. Il presente studio mira a indagare gli effetti dei videogiochi di sport estremi in realtà virtuale (VR) sui livelli di stress, emozioni e ansia in uomini con disturbo d'ansia sociale. **Metodi**. Adottando un disegno quasi-sperimentale con valutazioni pre-test, post-test e follow-up a 30 giorni, lo studio ha reclutato 84 uomini con diagnosi di Disturbo d'Ansia Sociale (SAD) tramite campionamento di convenienza da cliniche psicologiche e associazioni per l'ansia a Teheran, Iran. I partecipanti sono stati assegnati casualmente a un gruppo sperimentale (n = 42) o a un gruppo di controllo (n = 42). L'intervento sperimentale consisteva in una serie di simulazioni immersive in VR basate su sport estremi, mentre il gruppo di controllo partecipava a routine di esercizio fisico standard non in VR. Per la misurazione degli esiti principali è stata utilizzata la Depression, Anxiety, and Stress Scale, somministrata in tutte e tre le fasi di valutazione. L'analisi dei dati è stata condotta mediante Analisi della Covarianza (ANCOVA), controllando i punteggi basali come covariate; successivamente, sono stati effettuati confronti a coppie con correzione di Bonferroni per esaminare le variazioni specifiche tra i diversi momenti temporali. **Risultati**. L'intervento in VR ha prodotto riduzioni significative nei livelli di depressione (post-test η^2 parziale = .283; follow-up $\eta^2 = .261$), ansia (post-test $\eta^2 = .320$; follow-up $\eta^2 = .301$) e stress (post-test $\eta^2 = .341$; follow-up $\eta^2 = .327$; tutti $p < .001$). I confronti a coppie hanno confermato marcate diminuzioni dal basale al post-test, in larga parte mantenute al follow-up di 30 giorni.**Conclusioni.** Questi risultati suggeriscono che i videogiochi di sport estremi in VR possano rappresentare un intervento sicuro e non farmacologico per uomini con questo disturbo, aprendo la strada a ulteriori ricerche approfondite nel settore. L'elevato coinvolgimento garantito da tali piattaforme digitali ha consentito ai soggetti di confrontarsi con le proprie paure in un ambiente controllato, facilitando dinamiche assimilabili alla terapia espositiva senza i rischi associati agli sport estremi reali.

Parole chiave. Ansia maschile, sport estremi, salute mentale maschile, realtà virtuale, SAD.

Introduction

Social anxiety disorder (social phobia) is a prevalent form of anxiety, marked by an intense, often debilitating fear of social or performance situations[1]. Individuals with SAD typically worry excessively about negative evaluation in everyday interactions – from casual conversation to public speaking – and frequently avoid or endure such situations with great distress[2]. Approximately one in ten people will experience social anxiety at some point in life[1,3]. It usually begins in adolescence or early adulthood and, if untreated, "can severely impair a person's daily functioning by impeding the formation of relationships, negatively affecting performance at work or school and reducing overall quality of life"[4]. In practice, social anxiety can lead sufferers to shun friendships or turn down promotions and other opportunities that involve social interaction[5]. Men with SAD are no exception: social anxiety can strain their interpersonal and occupational relationships and undermine their confidence in routine activities[6].

First-line treatments for social anxiety include cognitive-behavioral therapy (CBT) and pharmacotherapy (usually selective serotonin reuptake inhibitors)[7]. Evidence suggests that CBT is especially effective and has lasting benefits, whereas medications can have undesirable side effects and often require long-term use[8]. For example, large studies have found that antidepressant medications work for many patients, but improvements frequently fade once the pills are stopped[9]. In reality, many people with SAD never seek treatment at all: therapy can be hard to access, and stigma or personal preferences may lead individuals (men included) to avoid professional help[10]. As the NIH notes, "people with social anxiety disorder are less likely to seek help" from mental health providers[11]. Thus, untreated social anxiety often persists, continuing to impair life satisfaction and social functioning[1]. Because of these challenges with conventional treatments, non-drug approaches are increasingly recommended. Physical exercise and sports, in particular, have well-documented mental health benefits[11,12]. Regular exercise consistently reduces stress, depression and anxiety while boosting mood and self-esteem [13]. Meta-analyses and large reviews show that people who engage in physical activity report higher self-confidence and lower levels of anxiety and depressive symptoms than sedentary individuals[14]. In practical terms, engaging in sport can serve as a complementary strategy to "help manage anxiety symptoms and enhance self-confidence"[15]. Many clinicians now encourage patients to incorporate exercise routines or sporting activities as part of anxiety reduction programs[14,16].

Among exercise modalities, extreme sports are of special interest due to their intensity. Activities like rock climbing, paragliding, skydiving and big-wave surfing involve high speed, height, and a significant element of perceived danger[5]. The challenge and adrenaline rush of these sports trigger strong physiological arousal. Surprisingly, many participants report that such high-adrenaline experiences improve their psychological state. For instance, a recent survey of hundreds of rock climbers found that 73% felt climbing had positively impacted their mental health; moreover, a large majority of climbers rated the sport as more helpful for their anxiety than medications or traditional therapy[17]. More generally, research suggests that involvement in extreme or adventure sports can enhance well-being: participants often gain greater confidence, resilience and a sense of achievement[18]. However, the very nature of extreme sports also poses barriers for anxious beginners. Individuals with low self-confidence or elevated anxiety may initially find the intensity overwhelming. Notably, social anxiety disorder frequently co-occurs with depression[19], which can dampen motivation to try challenging activities. On top of psychological hurdles, there are real physical dangers. Studies show that extreme sports carry a substantially higher risk of injury or even death than ordinary sports[20]. Inexperienced or novice participants are especially at risk: one review found that injury rates are much higher among newcomers who are just starting these activities[21]. Given these factors, asking socially anxious men to confront real-world extremes can be impractical or unsafe.

Virtual reality (VR) offers a promising solution by simulating high-stress environments without real danger. Immersive VR systems can recreate the sights, sounds, and even the physiological stress of activities like rock climbing or skydiving inside a controlled setting. Importantly, systematic reviews of VR for social anxiety indicate that VR-based exposure therapies are generally effective, safe, and well accepted by users[19,22]. In a VR scenario, a participant can "experience" the thrills of an extreme sport while remaining physically secure. This controlled exposure allows gradual habituation to intense stimuli: individuals with SAD can build confidence by facing simulated stressors step by step, free from the real-life consequences of a fall or accident[20]. In short, VR combines the benefits of exercise-induced arousal with the safety of a training simulator, making it an attractive non-pharmacological intervention for anxiety disorders[5,16,19]. In this regard, the present study will therefore test whether VR-based extreme sports games can alleviate anxiety, stress, and depression in men with social anxiety disorder. In a quasi-experimental design, socially anxious men will engage in a series of VR extreme-sport sessions while valid scales measure changes in their symptoms. By comparing pre- and post-intervention scores, we aim to quantify both the positive and any unintended negative effects of this immersive exercise. If successful, this approach could offer a novel therapeutic tool: a non-drug, game-like intervention to improve self-confidence and reduce anxiety in affected men. Given the rapid advances in VR technology and the growing interest in digital mental health, combining virtual adventure sports with evidence-based therapy may represent an important step toward more engaging and effective treatments for social anxiety and related conditions.

Methods

Research paradigm

This study utilized a quasi-experimental design with two parallel arms: an experimental group and a control group. The experimental intervention consisted of a program of extreme sports simulations (e.g., rock climbing and skydiving) delivered via an immersive virtual reality (VR) platform. In contrast, the control group participated in standard, non-VR physical exercises, such as swimming and cycling, which are comparable in duration and intensity to the VR sessions. To evaluate the intervention's effectiveness, a repeated-measures framework was implemented across three time points: pre-test (baseline), immediate post-test (following the intervention), and a 30-day follow-up assessment. This design allowed for the examination of both short-term and sustained effects of VR-based extreme sports games on psychological outcomes. Specifically, levels of anxiety, depression, and stress were measured at each stage. The inclusion of the follow-up phase was particularly important for assessing the durability of treatment effects beyond the immediate intervention period. Statistical analyses were conducted using analysis of covariance (ANCOVA) to control for baseline differences, complemented by post hoc pairwise comparisons of mean scores to detect specific group differences across time points. This methodological approach enhanced the rigor of the study by enabling both overall group comparisons and detailed evaluation of changes between successive measurement occasions.

Participant recruitment and characteristics

The study sample consisted of adult men clinically diagnosed with social anxiety disorder, drawn from psychological centers and associations in Tehran, Iran. Recruitment was carried out through convenience sampling. Initially, 100 individuals expressed interest in the study after announcements were shared within local mental health and counseling centers that provide services for anxiety- and stress-related disorders. Following an introductory briefing session, participants were informed of the voluntary nature of the research and their right to withdraw at any stage without penalty.

After applying the eligibility criteria and confirming diagnoses, 84 participants were retained and randomly allocated into two groups: an experimental group (n = 42) and a control group (n = 42). Diagnostic verification was performed using participants' clinical case files, and all diagnoses were reconfirmed by a licensed psychologist specializing in anxiety disorders. Ultimately, these 84 participants completed the full assessment protocol and successfully progressed through the study's intervention and testing phases. The study cohort comprised 84 male participants, with a mean age falling within the 31-35 year bracket, which represented the largest demographic (33.3%). The majority of participants were married (69.0%, n=58), while 31.0% (n=26) were single. Regarding the clinical history, nearly half of the sample (48.8%) had been living with the diagnosis for 3 to 5 years, followed by those diagnosed within 1-2 years (26.1%) and 6-8 years (25.0%).

Procedural framework

Following the initial recruitment phase, baseline assessments of anxiety, depression, and stress were conducted for all participants utilizing the Psychological Distress Inventory (PDI-21). Subsequently, the study protocol was implemented, wherein the experimental cohort was exposed to simulated extreme sports activities via an immersive virtual reality (VR) platform. Concurrently, the control group partook in standard, non-VR physical training routines. The VR intervention protocol was structured over a series of 14 sessions, scheduled twice weekly. Each session had a duration ranging from 30 to 40 minutes. Participation in the study was entirely voluntary, and all sessions were provided without charge to facilitate involvement and acknowledge the contribution of the subjects. After the conclusion of the intervention period for both groups, the PDI-21 was re-administered as a post-test evaluation to assess potential changes in the psychological outcome measures.

Instrumentation and metrics

To quantify the primary psychological constructs under investigation, this study employed the Psychological Distress Inventory (PDI-21), a instrument originally developed by Lovibond. The PDI-21 was selected for its robust psychometric properties and concise format[23]. To enhance its contextual validity for the specific demographic profile of the cohort, the instrument underwent a minor modification: following consultations with a panel of clinical psychologists, one supplemental item was integrated into the anxiety subscale to ensure comprehensive coverage of the construct relevant to the study's framework. The internal consistency of the instrument's subscales was rigorously evaluated using Cronbach's alpha. The analysis demonstrated excellent reliability, with coefficients of .97 for the depression subscale, .92 for anxiety, and .95 for stress, all surpassing conventional thresholds for high reliability in psychological research. The final adapted instrument comprised a total of 27 items. This included a 5-item section dedicated to collecting essential demographic and baseline characteristics. Responses were recorded on a Likert-type scale, ranging from 0 (Did not apply to me at all) to 3 (Applied to me very much, or most of the time).

Data analysis strategy

Prior to conducting the main analyses, data screening procedures were implemented. The Kolmogorov–Smirnov test indicated that the distribution of scores for all variables conformed to normality assumptions, as no significant deviations were detected ($p > .05$). Homogeneity of variances between the experimental and control groups was assessed using Levene's test, and results supported the equality of error variances across groups ($p > .05$). These findings confirmed that the assumptions required for parametric testing were satisfied. To examine group differences while adjusting for baseline scores, analysis of covariance (ANCOVA) was employed, with pre-test values entered as covariates. This approach provided a more precise estimation of intervention effects compared to separate ANOVAs, which were not conducted to avoid redundancy and inconsistencies[24]. Beyond overall model effects, post hoc pairwise comparisons of adjusted mean scores were performed to determine specific differences between the experimental and control groups at the post-test and 30-day follow-up stages. A Bonferroni correction was applied to control for Type I error across the three outcome domains (anxiety, depression, and stress). Effect sizes were reported using partial eta squared ($\eta^2 p$), with interpretation based on Cohen's (1988) guidelines: 0.01 (small), 0.06 (medium), and 0.14 (large). Statistical significance was set at $p < .05$ for all analyses. All computations were carried out using SPSS software.

Implementation of the VR intervention protocol

To ensure the fidelity, clarity, and therapeutic validity of the VR intervention, the research team collaborated with three specialists in VR application development, sports psychology, and kinesiology. The intervention was structured as a 14-session program conducted over seven consecutive weeks, with two sessions per week. Each session lasted between 30 and 40 minutes and was delivered using the Pico Neo 3 Pro VR headset (256GB capacity), providing high-resolution immersive environments. Orientation and Safety Procedures. All participants in the experimental group attended an orientation session prior to the intervention. During this session, the purpose of the study, safety protocols, and the mechanics of VR navigation were explained. Participants were also introduced to grounding techniques (e.g., paced breathing) to manage potential discomfort during exposure to virtual height or speed. Sessions were conducted in a dedicated laboratory space under the supervision of both a certified fitness instructor and a VR technical operator. Emergency stop mechanisms were clearly explained, and participants retained the option to discontinue any simulation at will. Also a certified fitness instructor managed exercise intensity and safety; a VR technical operator handled device setup, tracking boundaries, and emergency stop functions. Instructor-to-participant ratio was ≤1:6. Safety protocols included clear stop criteria (dizziness, nausea, panic exacerbation, BP red flags), immediate scenario exit, and seated recovery.

Structure of training sessions.
Each VR session consisted of three phases

Warm-up and Familiarization (5 minutes): participants engaged with simple virtual environments (e.g., virtual walking trails or balance exercises) to adapt to the headset and controls.

Extreme Sports Simulation (20–25 minutes): participants were exposed to immersive simulations of extreme sports, including rock climbing, bungee jumping, wingsuit flying, and skydiving. The tasks were designed to gradually escalate in intensity across sessions—from moderate challenges (low-altitude climbs, short jumps) to high-intensity scenarios (free falls, high-altitude flights).

Task Goals: participants were instructed to maintain balance, navigate paths, or complete virtual courses, while focusing on regulating their breathing and sustaining attention.

Psychological Targets: the sports simulations were selected to elicit moderate stress and excitement, thereby engaging exposure mechanisms relevant to social anxiety (i.e., tolerating elevated arousal in controlled settings).

Cool-down and Reflection (5–10 minutes): following the simulation, participants were guided to reflect on their emotional responses, record perceived anxiety/stress levels, and practice relaxation exercises. This phase was designed to consolidate adaptive coping strategies and facilitate transfer of skills beyond the VR environment.

Progression of Difficulty: the VR protocol followed a graded exposure framework, where the difficulty level of each session was increased incrementally. Early sessions emphasized familiarity and low-threat scenarios, while later sessions incorporated higher complexity (e.g., longer climbs, faster speeds, greater heights). This progression was intended to mirror the gradual exposure principles of cognitive-behavioral therapy while leveraging the motivational aspects of gamified sports.

Control Group

To provide a valid comparison condition, the control group participated in a structured program of standard physical training that matched the VR sessions in frequency, duration, and overall intensity. The control intervention was carefully designed to isolate the specific contribution of VR-based extreme sports by ensuring that both groups were exposed to comparable amounts of physical exertion, but through fundamentally different modalities.

Type of Activities: the control group engaged in conventional aerobic and resistance-based exercises that are commonly prescribed for general health and stress reduction.

Activities included: swimming sessions in a supervised indoor pool, focusing on moderate continuous laps (20–25 minutes per session).

Stationary cycling using gym-based ergometers, with resistance levels adjusted to maintain moderate exertion (target heart rate: 60–70% of age-adjusted maximum). Body-weight resistance routines such as push-ups, squats, and planks, performed under the supervision of a certified trainer. These activities were rotated across the 14 sessions to maintain variety and engagement while avoiding monotony. Each session lasted approximately 30–40 minutes, mirroring the VR intervention schedule.

Rationale for Control Condition: real-world extreme sports were not selected for the control condition due to three critical considerations:

Safety Concerns: participants with clinically significant social anxiety disorder may be at elevated risk for accidents and adverse events if asked to perform high-risk activities such as rock climbing or skydiving.

Feasibility: logistical and financial barriers (specialized equipment, travel, and insurance requirements) make the use of real extreme sports impractical in controlled experimental research.

Experimental Integrity: the purpose of the control group was not to replicate extreme sports, but to provide an active physical training condition that allowed the effects of VR immersion and gamification to be isolated from those of general physical exercise.

Results

The Kolmogorov-Smirnov (K–S) test was conducted to assess the normality of the distribution for depression, anxiety, and stress scores across the control and experimental groups at pre-test, post-test, and 30-day follow-up stages. The results are summarized in table 1.

For all variables - depression, anxiety, and stress - the K–S test yielded non-significant p-values (p = .200

Table 1. Kolmogorov-Smirnov Test.

Variable	Group	K–S (D)	p-value
Pre-test – Depression	Control	.090	.200
	Experiment	.082	.200
Pre-test – Anxiety	Control	.088	.200
	Experiment	.095	.200
Pre-test – Stress	Control	.097	.200
	Experiment	.101	.200
Post-test – Depression	Control	.092	.200
	Experiment	.089	.200
Post-test – Anxiety	Control	.094	.200
	Experiment	.097	.200
Post-test – Stress	Control	.099	.200
	Experiment	.103	.200
Follow-up (30-day) – Depression	Control	.091	.200
	Experiment	.086	.200
Follow-up (30-day) – Anxiety	Control	.096	.200
	Experiment	.093	.200
Follow-up (30-day) – Stress	Control	.098	.200
	Experiment	.102	.200

for all comparisons), indicating that the data for both groups (control and experimental) followed a normal distribution at each measurement point (pre-test, post-test, and follow-up). The K–S statistic (D) ranged between .082 and .103, further supporting the assumption of normality, as none of the values exceeded the critical threshold for rejecting normality. These findings confirm that parametric statistical tests (e.g., ANOVA, t-tests) are appropriate for analyzing the data, as the normality assumption was met for all variables across groups and time points.

Levene's Test: table 2 presents the results of Levene's test, which assessed the equality of error variances for depression, anxiety, and stress scores across the control and experimental groups at pre-test, post-test, and 30-day follow-up. For all variables and time points, the test yielded non-significant results ($p > .05$), with F-values ranging from 0.84 to 1.18. These findings indicate that the assumption of homogeneity of variance was met ($p = .282$–$.364$), supporting the validity of subsequent parametric analyses (e.g., ANCOVA).

Based on the ANCOVA results (table 3) demonstrated significant reductions in depression, anxiety, and

Table 2. Levene's Test of equality of error variances.

Variable	F	df1	df2	p-value
Pre-test – Depression	1.12	1	58	.295
Pre-test – Anxiety	0.84	1	58	.364
Pre-test – Stress	0.97	1	58	.329
Post-test – Depression	1.05	1	58	.310
Post-test – Anxiety	0.91	1	58	.345
Post-test – Stress	1.18	1	58	.282
Follow-up (30-day) – Depression	0.88	1	58	.352
Follow-up (30-day) – Anxiety	1.07	1	58	.305
Follow-up (30-day) – Stress	1.15	1	58	.289

Table 3. ANCOVA Results for depression, anxiety, and stress (post-test and follow-up).

Variable	Group	SS	df	MS	F	p-value	Partial η^2
Depression (Post-test)	Pre-test (covariate)	12.45	1	12.45	6.12	.016	.097
	Group	45.78	1	45.78	22.48	< .001	.283
	Error	116.14	57	2.04	-	-	-
Depression (Follow-up, 30-day)	Pre-test (covariate)	10.87	1	10.87	5.64	.021	.090
	Group	41.23	1	41.23	20.15	< .001	.261
	Error	116.49	57	2.04	-	-	-
Anxiety (Post-test)	Pre-test (covariate)	14.31	1	14.31	7.25	.009	.113
	Group	52.92	1	52.92	26.79	< .001	.320
	Error	112.62	57	1.98	-	-	-
Anxiety (Follow-up, 30-day)	Pre-test (covariate)	13.09	1	13.09	6.89	.011	.108
	Group	49.11	1	49.11	24.52	< .001	.301
	Error	114.10	57	2.00	-	-	-
Stress (Post-test)	Pre-test (covariate)	15.22	1	15.22	7.68	.008	.119
	Group	58.36	1	58.36	29.46	< .001	.341
	Error	112.84	57	1.98	-	-	-
Stress (Follow-up, 30-day)	Pre-test (covariate)	14.77	1	14.77	7.41	.009	.115
	Group	55.19	1	55.19	27.69	< .001	.327
	Error	113.54	57	1.99	-	-	-

stress for the VR-based intervention group compared to the control group at both post-test and 30-day follow-up ($p < .001$ for all group effects). Pre-test scores were a significant covariate ($p < .05$), confirming the validity of the analysis. Effect sizes (partial η^2) ranged from .261 to .341, indicating large and clinically meaningful improvements across all outcomes.

For depression, the intervention showed large effects at post-test (partial $\eta^2 = .283$, $p < .001$) and follow-up (partial $\eta^2 = .261$, $p < .001$). Similarly, anxiety levels decreased substantially (post-test: partial $\eta^2 = .320$; follow-up: partial $\eta^2 = .301$, both $p < .001$). Stress also exhibited significant reductions, with the strongest effect at post-test (partial $\eta^2 = .341$) and sustained improvement at follow-up (partial $\eta^2 = .327$, both $p < .001$).

As presented in table 4, the post-hoc test results revealed the following: in the control group, none of the comparisons between pre-test, post-test, and follow-up assessments showed significant differences ($p > .05$), indicating that levels of depression, anxiety, and stress remained stable in the absence of intervention. In the experimental group, a significant reduction in depression, anxiety, and stress was observed from pre-test to post-test ($p < .001$). Furthermore, comparisons between pre-test and the 30-day follow-up demonstrated that these reductions were sustained over time ($p < .001$). No significant differences were found between post-test and follow-up ($p > .05$), suggesting the stabilization and maintenance of the virtual reality intervention's effects. Overall, the findings indicate that virtual reality-based sports games not only effectively reduced depression, anxiety, and stress in men with social anxiety disorder but also maintained these positive effects even one month after the intervention.

For clarity in presenting the test results, figure 1 explicitly compares the relevant outcomes in a clear and illustrative manner.

Discussion

This quasi-experimental study investigated whether immersive VR extreme-sports games reduce symptoms of depression, anxiety, and stress among men with Social Anxiety Disorder (SAD), and whether such effects persist at a 30-day follow-up. Overall, VR intervention participants showed statistically and clinically meaningful reductions across all three outcome domains relative to the control group; group effects were large (post-test partial η^2: depression = .283, anxiety = .320, stress = .341) and remained substantial at follow-up (partial η^2: depression = .261, anxiety = .301, stress = .327; all group $p < .001$). These results indicate both immediate and medium-term benefits of VR extreme-sports exposure for men with SAD.

Table 4. Pairwise comparisons of mean scores (pre-test, post-test, follow-up).

Variable	Group	Compration	Mean Diff.	Std. Error	p-value
Depression	Control	Pre → Post	-0.32	0.28	.264
		Pre → Follow-up	-0.28	0.29	.315
		Post → Follow-up	+0.04	0.21	.842
	Experiment	Pre → Post	-4.12	0.35	< .001
		Pre → Follow-up	-3.89	0.37	< .001
		Post → Follow-up	+0.23	0.22	.301
Anxiety	Anxiety (Post-test)	Pre → Post	-0.41	0.31	.201
		Pre → Follow-up	-0.36	0.30	.242
		Post → Follow-up	+0.05	0.24	.829
	Anxiety (Follow-up, 30-day)	Pre → Post	-4.65	0.33	< .001
		Pre → Follow-up	-4.41	0.36	< .001
		Post → Follow-up	+0.24	0.23	.298
Stress	Stress (Post-test)	Pre → Post	-0.27	0.29	.345
		Pre → Follow-up	-0.22	0.28	.418
		Post → Follow-up	+0.05	0.23	.824
	Stress (Follow-up, 30-day)	Pre → Post	-5.03	0.34	< .001
		Pre → Follow-up	-4.78	0.35	< .001
		Post → Follow-up	+0.25	0.24	.290

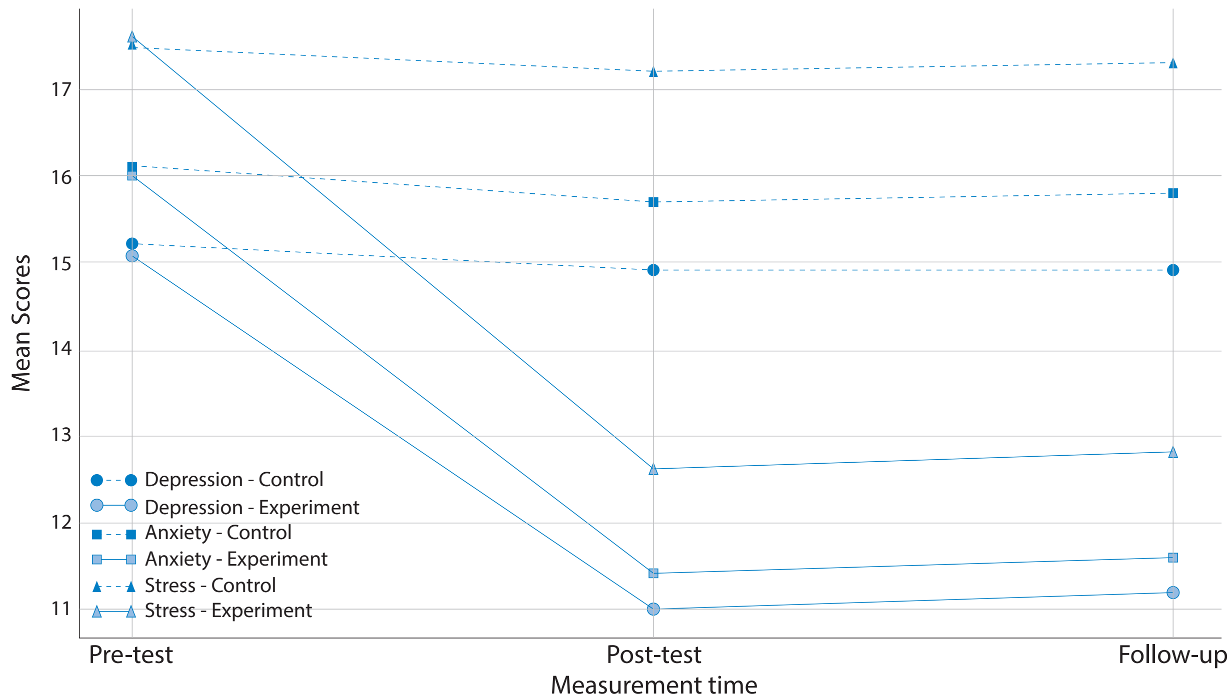

Figure 1. Changes in depression, anxiety and stress across time.

Mechanisms underlying these effects are likely multifactorial. Firstly, immersive VR offers graded and controllable exposure to both interoceptive and situational cues within a safe setting, a central component of exposure-based therapies that fosters habituation and weakens conditioned fear responses[25]. Meta-analytic evidence supports this: for example, a recent meta-analysis on Virtual Reality Exposure Therapy (VRET) for Social Anxiety Disorder indicated large effect sizes at post-intervention and sustained improvements at follow-ups (3-months, 6-months) that were comparable to in-vivo exposure (Hedges' g ≈ -1.0)[26]. Secondly, the convergence of physical exertion (even when movement is simulated or partially supported) with heightened attentional engagement can trigger beneficial neurophysiological cascades. For example, recent VR exergaming studies demonstrate enhanced affective response and executive function, and physiological markers of stress regulation, in young adults after sessions of moderate to high intensity VR exercise—suggesting increases in endorphins, monoamines, and possibly neurotrophic factors that underpin mood regulation and resilience to stress[27]. Thirdly, participation in challenging but manageable VR scenarios promotes perceived self-efficacy and mastery. Overcoming simulated "extreme" challenges reinforces personal agency and reduces avoidance behavior, which are critical in alleviating social anxiety[28]. Outdoor adventure-based interventions similarly show significant improvements in general self-efficacy and reductions in perceived stress following exposure to high-ropes or challenge courses, especially among participants who begin with lower baseline self-efficacy[29]. In this regard, the present study's findings align with and extend this existing body of evidence. The significant reduction in psychological distress observed in our experimental group suggests that the unique synergistic combination of three key elements – physical exercise, extreme sport simulation, and immersive virtual reality – creates a potent therapeutic modality. This integrated approach appears to capitalize on the distinct mechanisms outlined above simultaneously: the controlled exposure provided by VR, the neurophysiological benefits of physical exertion, and the self-efficacy gains from mastering extreme challenges. It is precisely this intelligent amalgamation, previously unexplored in such a configuration, that likely underpins the pronounced positive effects on reducing anxiety, depression, and stress metrics in our sample.

The pronounced reduction in anxiety symptoms observed in the present study is strongly corroborated by the extant literature on virtual reality interventions. The substantial decrease aligns with the efficacy established for Virtual Reality Exposure Therapy (VRET) in treating social anxiety disorder (SAD). For instance, a recent meta-analysis by Tan et al. consolidating evidence from 17 randomized controlled trials concluded that VRET yields significant and large-magnitude reductions in anxiety symptoms compared to waitlist controls, with effects persisting at follow-up assessments[30]. This convergence suggests that the immersive VR component of our intervention successfully provided the graded, controlled exposure necessary for habituation and fear extinction, a mechanism central to VRET. Furthermore, the specific format of our intervention – integrating physical exertion with VR – finds support in emerging research on VR exergaming. The work of Yuxinet al. (2025), for example, demonstrated that VR-based exercise led to greater reductions in anxiety among college students than traditional aerobic activities[31]. This reinforces the premise that the combination of physiological arousal from exercise and the cognitive engagement required by the virtual environment may produce a synergistic anxiolytic effect, potentially through enhanced neurobiological pathways related to stress regulation. The stability of the anxiety reduction at the 30-day follow-up in our cohort is particularly noteworthy and echoes the sustained benefits reported in systematic reviews, such as the one by Christianet al., which confirmed substantial anxiety reductions with stand-alone VRET[32]. The consistency of our findings with this body of evidence strengthens the inference that the multi-component intervention employed here – merging VR, extreme sports, and physical activity – produces robust and durable anxiolytic effects, likely by simultaneously engaging the key therapeutic mechanisms of exposure, physiological regulation, and self-efficacy enhancement.

Regarding the stress-related variable, the notable decrease observed underscores the potential of immersive environments to induce a state of psychological detachment and facilitate recovery from stressors. This finding is consistent with the outcomes of an RCT comparing BOXVR to guided video workouts in adolescents, which reported superior stress reduction in the VR exergaming condition[33]. This alignment suggests that the active, engaging nature of VR physical activity may be more effective than traditional formats in interrupting the cycle of stress by demanding focused attention and providing a compelling distraction from ruminative thoughts. Additionally, the particular responsiveness of stress to our VR intervention is further supported by a home-based VR training pilot study, where perceived stress emerged as the primary outcome showing significant improvement, even when changes in other psychological constructs were not evident[34]. This pattern indicates that stress levels may be especially susceptible to the restorative and absorbing qualities of immersive virtual environments. The mechanism is corroborated by research such as that of Lotfinia et al., which demonstrated that even brief exposures to relaxing VR scenarios (e.g., nature environments) can yield significant psychological and physiological stress reduction[35]. Although conducted in a different clinical population, this study reinforces the notion that VR immersion itself can promote relaxation and buffer against stress, an effect likely amplified in our protocol by the addition of physical exertion.

Finally, regarding depression, the observed substantial reduction in symptoms is consistent with a growing body of evidence demonstrating the antidepressant effects of VR-based activities. For example, a recent randomized controlled trial on virtual reality stationary cycling revealed that participants engaging in both high and moderate-intensity VR cycling experienced significantly greater reductions in depression scores compared to those in a non-VR cycling group[36]. This finding strongly corroborates our results, suggesting that the immersive quality of VR adds a critical component that enhances the mood-lifting benefits of physical exercise alone, potentially by increasing engagement and fostering a sense of presence and distraction from negative ruminations. Further supporting this notion, an 8-week RCT investigating the effects of a VR-based exercise intervention on college students found that improvements on the depression subscale were more pronounced in the VR group than in both traditional exercise and control conditions[31]. This aligns with the observed trajectory in our study, indicating that the structured, engaging nature of VR exergaming can be particularly effective in alleviating depressive symptoms. The improvement in depression, even in interventions primarily targeting anxiety, is a recognized phenomenon. A study on smartphone-based VRET for social anxiety reported moderate to large effect sizes for the reduction of co-occurring depressive symptoms, highlighting that successfully navigating anxiety-provoking virtual scenarios can generate a generalized sense of accomplishment and agency that positively impacts mood[37]. While systematic reviews, such as the one from 2020, often note that reductions in depression within SAD populations can be a secondary outcome with somewhat smaller effect sizes than those for anxiety[25], the robust and sustained decrease maintained at follow-up in our study is particularly significant. It reinforces the argument that the tripartite intervention – merging the physiological benefits of exercise, the engaging distraction of VR, and the mastery experiences of extreme sports – creates a powerful synergistic effect capable of producing meaningful and durable change in depressive symptomatology.

Conclusion

In conclusion, the findings of this study provide compelling evidence that a structured intervention integrating immersive virtual reality simulations of extreme sports with physical exertion is a highly effective modality for alleviating symptoms of anxiety, stress, and depression in men with social anxiety disorder. The significant, large-sized improvements observed across all psychological outcomes, which were notably maintained at the 30-day follow-up, underscore the durability of the effects. This investigation advances the field by demonstrating that the synergistic combination of three core components – the controlled exposure inherent in VR, the neurophysiological benefits of exercise, and the self-efficacy gains from mastering challenging scenarios – creates a potent therapeutic synergy. Ultimately, this approach presents a promising, engaging, and scalable non-pharmacological option for enhancing mental well-being.

Conflicts of interest. The authors declare that there is no conflict of interest.

Authors' contributions. All authors have significantly contributed to the work reported, including conception, study design, execution, data acquisition, analysis, and interpretation, or a combination of these areas. They have actively participated in drafting, revising, or critically reviewing the article, provided final approval for the version to be published, agreed on the journal for submission, and accepted accountability for all aspects of the work.

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Ethics approval and consent to participate. The research protocol was reviewed and approved by the Institutional Review Board (IRB) of the relevant ethics committee, as evidenced by the Ethical Approval ID: IR.SSRC.REC.1404.029, issued on Approval Date: 2025-05-03. All procedures adhered to the principles of confidentiality, voluntary participation, and minimal risk, ensuring the protection of participants' rights and well-being throughout the study.

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