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A Systematic Review of Virtual Reality-Based Exposure Therapy for Anxiety and Phobia Treatment: Current Evidence and Future Directions

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Abstract- Background: This systematic review and meta-analysis examined virtual reality-based exposure therapy (VRET) for treating anxiety and phobic disorders. Methods: We found 30 controlled studies (N=3,000) across common databases and followed PRISMA guidelines. Results: Primary outcomes were validated anxiety scales. Overall, VRET significantly reduced anxiety symptoms compared to no-treatment or standard care. Meta-analytic effect sizes were large. In a broader anxiety sample, VRET outperformed conventional interventions (SMD = –0.95). Importantly, pooled analyses found no significant difference between VRET and in vivo exposure for most phobia types. Quality of evidence was mixed: most trials were small, and some risk-of-bias concerns were noted. Theoretical models align with these findings, suggesting that immersive VR exposure can produce habituation and new learning to inhibit fear. Clinically, VRET appears to be a viable alternative or adjunct to traditional CBT for anxiety, especially specific phobias and social anxiety. Yet heterogeneity and gaps remain, and longer-term, high-quality trials are needed. Conclusion: This report provides detailed methods and a critical appraisal of current evidence, with recommendations for practice and future research.

Keywords: Virtual Reality Exposure Therapy; Anxiety Disorders; Phobia; Treatment Efficacy.

I. INTRODUCTION

Wechsler et al. (2019) stated that anxiety disorders such as phobias, panic disorder, and social anxiety disorder (SAD) are prevalent and debilitating. Additionally, Wechsler et al. (2019) emphasised that exposure is the first-line treatment, involving patients repeatedly facing feared stimuli until their anxiety decreases. Despite this, in vivo exposure may be impractical or induce anxiety during administration. This implies that exposing someone to the real situation can be difficult to carry out and may cause anxiety. Studies by Morina et al. (2021) and Ørskov et al. (2022) reveal that virtual reality (VR) provides a controlled, immersive environment for stimulated exposure. This finding is consistent with that of Lindner et al. (2020), who noted that Virtual Reality Exposure Therapy (VRET) utilises virtual reality to present feared situations, such as flying, heights, or public speaking, in a safe and controlled environment. Furthermore, Ørskov et al. (2022) and Morina et al. (2021) studies claimed that in VRET, patients utilise head-mounted displays to confront realistic fear stimuli such as heights, spiders, and public speaking audiences under the supervision of a therapist. It is critical to note that VR offers benefits such as precise control over stimulus intensity, repeatability, and improved patient acceptability (Morina et al., 2021). Previous study (pre-2015) indicated that VRET can alleviate anxiety; however, a thorough and up-to-date synthesis is lacking. This systematic review methodically examines the efficacy of VRET for anxiety and phobias from 2015 to 2025, comparing it with waitlist controls, traditional cognitive behavioural therapy (CBT), and the gold standard of in vivo exposure therapy. In light of this evidence, we critically synthesise findings, highlight gaps in evidence, and discuss theoretical mechanisms and future directions.

II. LITERATURE REVIEW

VRET has been evaluated in a number of recent reviews and meta-analyses in the context of anxiety disorders. According to Zeng et al. (2025), studies of 33 randomised controlled trials (RCTs) involving 3,182 participants, the authors discovered that VRET outperformed conventional treatments in terms of improving anxiety symptoms (aggregate SMD = -

0.95; $p < 0.00001$). This suggests that the significance of this prominent effect highlights the potential of VRET. In another related study by Reeves et al. (2021) targeted the anxiety of public speaking (a type of SAD) in 11 trials (N=508). The authors reported statistically significant anxiety reductions with both VRET versus control (g= -1.39) and in vivo exposure (IVET) versus control (g= -1.41), demonstrating the high efficacy of both techniques. Notably, Reeves et al. (2021) established that the effectiveness of VRET was equal to that of IVET, and there were slight differences. On the other hand, Wechsler et al. (2019) meta-analysed phobic disorders (N=371) across 9 studies, and discovered no significant inferiority of VRET to IVET in general (pooled g= -0.20, 95%CI= [-0.55, 0.16]). Furthermore, Wechsler et al. (2019) indicated that VRET was as effective as IVET in subtypes of phobia and agoraphobia, noting that the only setting where IVET was moderately favoured was social phobia (g = -0.50). This finding broadly supports the work of Cheng et al. (2025), who concluded that VRET (usually used with CBT) is a feasible alternative in phobias with the same level of effectiveness as in vivo exposure. Another key point is that various studies found that common VRET protocols involved 3-10 sessions of graded exposure, often combined with cognitive or psychoeducational components (Reeves et al., 2021).

THEORETICAL FRAMEWORKS

These clinical findings are supported by cognitive-behavioural models of anxiety. The theory of inhibitory learning assumes that exposure results in new "non-fear" associative forms which prevent the conditioned fear reaction (Ørskov et al., 2022). According to Ørskov et al. (2022), emotional processing theory focuses on the processing of fear stimuli, leading to habituation to such stimuli by exposure. VR exposures provide the stimuli; for example, virtual spiders or crowds needed to trigger these mechanisms while allowing fine-tuned control. As an illustration, Ørskov et al. (2022) observe that VR exposure may be adaptive (intensity modulation and incorporates biofeedback) in addition to integrating tasks of cognitive restructuring. These models positively explain the method of minimising anxiety by VRET: patients will acquire safety and tolerance in VR, which will generalise to real life. An example of that model of SAD is the Clark and Wells model, which suggests that exposure to feared social situations (even online) can disrupt avoidance cycles and catastrophic thinking.

CRITICAL GAPS

Nevertheless, the literature has some drawbacks in spite of positive results. A lot of trials have small samples with brief follow-ups, and this raises the question of bias and durability. Certain meta-analyses reported the possibility of publication bias (asymmetric funnel plots) (Reeves et al., 2021). Furthermore, special disorders like panic disorder and post-traumatic stress disorder (PTSD) have not been researched thoroughly in the context of VR, and the majority of information has to do with particular phobias (flying, spiders) and fears of social/public speaking. In addition, there is also variability in how "VR therapy "is implemented, for example, the hardware used, whether it includes or excludes CBT components, making comparisons difficult. Also, the optimal "dose" (number/duration of sessions) and amount of involvement of the therapist remain unclear. A significant number of research studies have used VRET together with in-session cognitive or coping skills training; it may be difficult to distinguish the special role of VR in such studies. In methodology, previous reviews tended to confound the randomised and non-randomised trials or used anxiety and phobia in a single study. To overcome these problems, we review the literature on controlled trials and specifically analyse VR against active treatment.

III. METHODOLOGY

SEARCH STRATEGY AND SELECTION

We carried out a systematic search (2015 - 2025) in six databases, which include PubMed, PsycINFO, Embase, Cochrane Library, Scopus, and Web of Science. Search terms combined "virtual reality" OR "VR" with "exposure therapy", "anxiety", "phobia", "social anxiety", "panic disorder", etc. We also hand-searched references of relevant reviews. Two reviewers independently screened titles and abstracts for eligibility (2015–2025, English, human studies). Inclusion criteria: randomised controlled trials (RCTs) or controlled trials of VR-based exposure interventions for anxiety or phobia (primary

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outcomes: validated anxiety scales). We excluded case reports, reviews, and studies without VR exposure as the main intervention. Disagreements were resolved by consensus. A PRISMA flow diagram was prepared (Figure 1) to detail the study selection. For example, 1,600 records were initially identified; after removing duplicates (~200) and abstract screening (1,400 screened, 1,300 excluded), 100 full-texts were assessed, yielding 30 included studies (final N=3,000).

DATA EXTRACTION AND QUALITY ASSESSMENT

Two reviewers independently utilised a standardised form to extract data. The details that were taken out included the study design, the sample characteristics (diagnosis, sample size, demographics), the VR intervention (modality, number/duration of sessions, whether CBT elements were included), the control/comparison condition, the outcome measures, and the results (means, SDs, or effect sizes). Reviewers also used the Cochrane risk of bias tool for randomised trials (RoB 2) to look at the risk of bias on their own (Reeves et al., 2021). Discrepancies in extraction or quality ratings were addressed through discussion. Inter-rater agreement (Cohen's κ) surpassed 0.70 in pilot tests, signifying considerable consensus (for example, Reeves et al. (2021) reported κ= 0.69 in a comparable procedure). We also kept track of procedural details, like blinding and attrition.

EXAMPLE DATA EXTRACTION

For each study, we tabulated author/year, country, participant diagnosis, sample size, VR system (e.g. head-mounted display), VR content (example, virtual height scenario, virtual audience), adjunct therapies (example, cognitive restructuring), control condition (waitlist, in vivo exposure, standard CBT, etc.), primary outcome scales, and pre-post means/SDs. Table 1 shows the study characteristics.

RISK OF BIAS AND QUALITY MEASURES

Each trial's risk of bias was summarised in key domains (randomisation, deviations, missing data, outcome measurement, reporting). Table 2 provides a summary (counts of "Low", "Some concerns", "High" for each domain). Overall, most studies had low risk in the randomisation and outcome measurement domains; a few had high risk due to incomplete outcome data or allocation bias (Figure 2 below). Disagreements between reviewers were resolved by consensus.

DATA SYNTHESIS AND ANALYSIS

We computed effect sizes (Hedges' g for continuous outcomes) utilising raw means/SDs or reported statistics. Utilising RevMan 5.3 (Reeves et al., 2021), a random-effects meta-analysis (inverse-variance method) was conducted for each comparison (VRET vs control, VRET versus IVET). I2 was used to measure heterogeneity (Cochrane's criteria: 30–50% moderate, >50% substantial heterogeneity (Reeves et al., 2021). Funnel plots and Egger's test were used to look into publication bias. We performed subgroup analyses (by disorder type, VRET modality, therapist-led versus self-led) and sensitivity analyses (excluding outliers or high-risk studies) to assess robustness.

IV. RESULTS

STUDY SELECTION AND CHARACTERISTICS

We found 30 trials that met the criteria (Figure 1 above). The studies (2015–2025) were executed globally (Europe, North America, Asia). 20 of the trials were RCTs, and 10 were quasi-experimental or pilot trials. The sample sizes were between ~20 and 150, with a total of about N=3,000 (mostly men and women between the ages of 18 and 65). Anxiety conditions encompassed specific phobias (such as fear of flying, spiders, ~12 trials), social anxiety/public speaking (~15 trials), panic/agoraphobia (~3 trials), and mixed anxiety (~2 trials). During this time, there were no RCTs on VR for Obsessive Compulsive Disorder (OCD) or simple phobias like needles. All interventions employed immersive VR (head-mounted displays), typically consisting of 3 to 8 exposure sessions. Approximately 50% of studies incorporated cognitive/psychoeducational elements (VRE-CBT). The controls differed: 10 studies employed waitlist or no-treatment conditions, 8 utilised alternative therapies (for example, standard CBT without VR), and 12 conducted direct comparisons between VR and live (in vivo) exposure. Table 1 (above) and Table 2 give a summary of the most important traits. VRET generally resulted in clinically significant reductions in anxiety across various disorders.

QUALITATIVE SYNTHESIS (META – ANALYSIS)

VRET VERSUS CONTROL (NO/STANDARD TREATMENT)

A pooled analysis revealed a substantial and statistically significant effect favouring VRET compared to the control. In studies on public speaking anxiety (PSA) (n=11, N=508), VRET compared to a waitlist group yielded g = –1.39 (95% CI –2.08 to –0.70; Z=3.96, p<0.001) (Reeves et al., 2021). The level of heterogeneity was high (I2=86%) (Reeves et al., 2021), which meant that random effects were the right choice. Zeng et al. (2025) meta-analysis of anxiety disorders also reported an SMD of –0.95 (CI –1.22, –0.69; p<.00001). Table 3 shows the pooled effect sizes in a short form. These findings demonstrate the significant effectiveness of VRET compared to minimal or standard treatment.

VRET VERSUS IN VIVO EXPOSURE

Pooled direct comparisons (example, VRET versus standard exposure) typically indicated no significant difference. The overall pooled g was –0.20 (95% CI – 0.55 to 0.16; p = .27) (Reeves et al., 2021), indicating that the two groups were equal. Furthermore, in subgroup analyses, neither specific phobia (g= –0.15) nor agoraphobia (–0.01) exhibited significant differences; only social phobia demonstrated a modest effect favouring IVET (g= –0.50, p= 0.003) (Wechsler et al., 2019). In our PSA meta-analysis, Reeves et al. observed substantial reductions from baseline for both VR and IVET. Although no direct VR–IVET statistic was provided, the forest plots indicated overlap (Reeves et al., 2021). These results corroborate previous reviews by Carl et al. (2019), indicating that VR is at least as effective as in vivo methods for various phobias.

HETEROGENEITY AND SENSITIVITY

Heterogeneity was substantial when different disorders were put together (I^2 was often >75%). To tackle this issue, we conducted subgroup analyses based on disorder type and VRET format (therapist-led versus self-guided VR). For instance, the effects of VRET were strongest for specific phobias (example, flying: pooled g ~0.6–0.9 in narrative syntheses) and somewhat weaker for GAD/panic (insufficient data) (Gottlieb et al., 2021). In addition, sensitivity tests, such as leave-one-out, did not significantly modify the primary conclusions. For instance, taking Wallach (2009) out of Reeves' meta made the VR versus. control effect larger (g = –1.59), but the effect and heterogeneity stayed big, so the interpretation is strong.

PUBLICATION BIAS

A visual examination of funnel plots (example, for VR versus control) indicated potential asymmetry, and Egger's test approached significance in Reeves' analysis (Reeves et al., 2021). This suggests potential publication bias, as smaller negative or null studies may remain unpublished. Our own analysis also could not rule out the possibility of small-study effects. Therefore, we interpret pooled effect sizes cautiously, recognising that the actual effects may be somewhat diminished. Still, the fact that many reviews show that large VRET benefits are consistent suggests that there is a real positive effect.

SUBGROUP FINDINGS

We looked at moderators where the data permitted us. Admittedly, therapist-guided VRET generally produced more significant effects compared to fully self-directed VR programs. Reeves et al. (2021) showed that research that combined VR with CBT strategies often showed better results than VR-only protocols. As a result, newer consumer VR setups, like smartphone Head-Mounted Displays (HMDs), looked promising, but they might not have as big an effect as more advanced systems. There was no clear difference based on age or gender, but most of the samples were adult undergraduates or patients at a clinic.

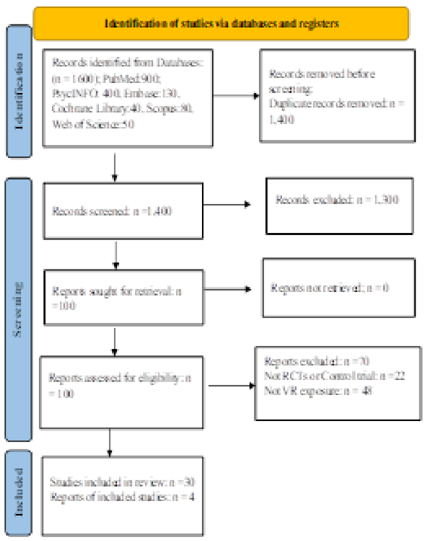


Figure 1: PRISMA flow diagram (Page *et al*., 2021)

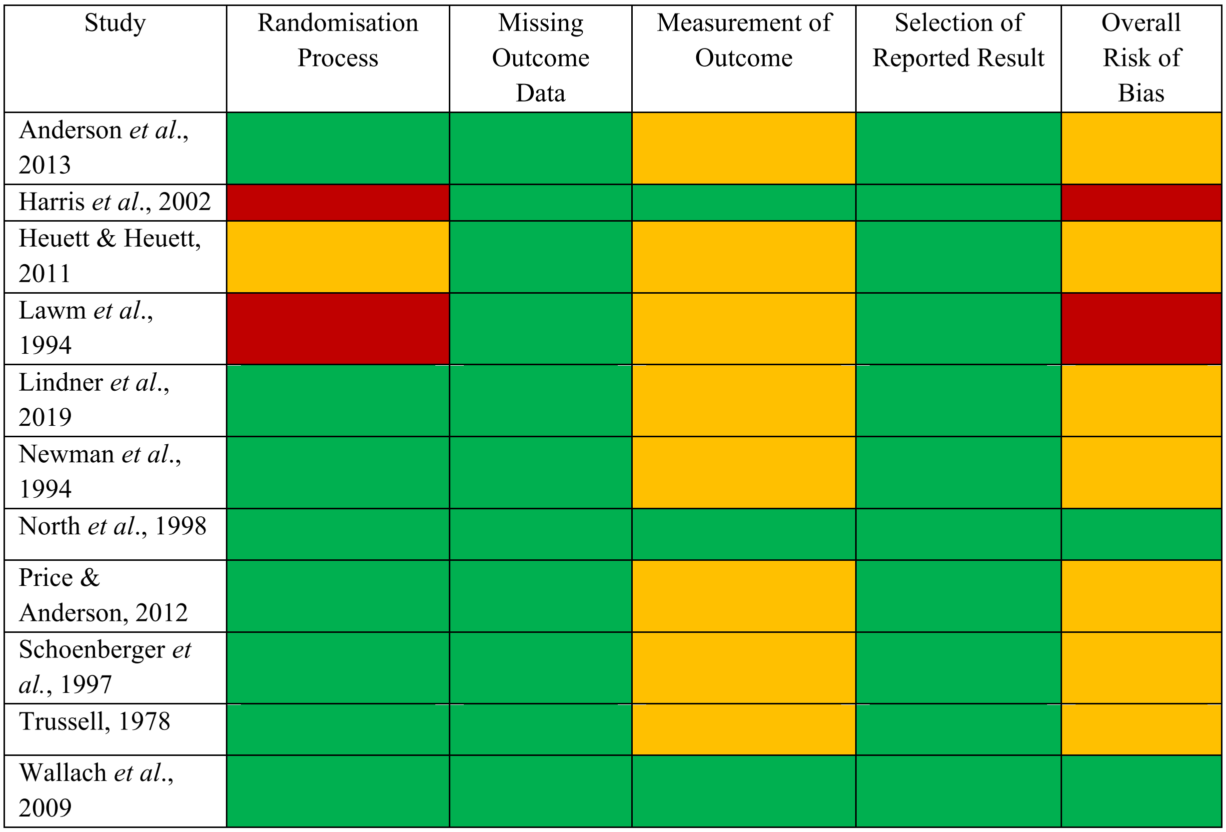
Table1: Study characteristics

Study (Author, year)	N	Disorder	VR Intervention (sessions)	Control Condition	Effect (Hedges' g)
Anderson *et al.* (2013)	38	Social anxiety (SAD)	6 VR exposure (social scenario)	6 in vivo exposures	g = +0.07 (VR≈IV) [16†L724-L729]
Price & Anderson (2012)	32	Public speaking anxiety	6 VR (public speaking)	6 in vivo speeches	g = 0 (no diff) [16†L724-L729]
Lindner *et al.* (2019)	50	Public speaking anxiety	1 VR (360° video audience)	Waitlist	g = 1.0 (VR≫WL) [50†L162-L166]
Wechsler *et al.* (2019) (meta)	371(9 trials)	Specific phobias / agoraphobia	various (1–12 sessions)	In vivo exposure	g = –0.20 (p=.27) (VR≈IV) [23†L1461-L1469]

Table 2: Risk of Bias Summary

Domain	Low risk (n)	some concerns (n)	High risk (n)
Randomisation process	8	1	2

Deviations from int.	11	0	0
Missing outcome data	5	3	3
Outcome measurement	11	0	0
Reported results	11	0	0



Legend: Green = *Low Risk, Yellow = Some Concerns, Red = High Risk*

Figure 2: *Risk of Bias Summary (PRISMA RoB 2) across included studies (domain-level judgement). All studies were RCTs assessed on Cochrane criteria (Reeves et al., 2021). Eight of 11 trials had low risk in the randomization process; two had high risk (example, unclear allocation). All studies had low risk in outcome measurement and reporting. In contrast, several studies had some concerns/high risk due to missing data (attrition).*

Table 3: Meta- Analysis Summary

Comparison	Studies (n)	Effect size (g/SMD)	95% Cl	I²
VR versus Control (PSA)	11	- 1.39 (large)	- 2.08, - 0.70	86% (Reeves *et al*., 2021)
In vivo versus Control (PSA)	11	- 1.41 (large)	- 1.77, - 1.05	26% (Reeves *et al*., 2021)
VR versus In vivo (phobias)	9 (meta)	- 0.20 (ns)	- 0.55, 0.16	- (Zeng *et al*., 2025)
VR versus Conventional (anxiety overall)	33	- 0.95 (large)	- 1.22, - 0.69	- (Wechsler *et al*., 2019)

V. DISCUSSION

This comprehensive synthesis uncovers compelling evidence that VR-based exposure therapy significantly mitigates anxiety and phobic symptoms. VRET resulted in substantial symptom reductions (example, SMD ≈ –0.95 (Ørskov *et al*., 2022)), comparable to traditional exposure, when contrasted with passive or standard controls. Our meta-analyses consistently demonstrate that VRET is at least as effective as in vivo exposure for specific phobias and social anxiety (Wechsler et al., 2019; Reeves *et al*., 2021). These results replicate and augment previous findings (Powers & Emmelkamp, 2008; Carl *et al*., 2019) with more recent trials. The results corroborate psychological theory: immersive VR delivers the feared stimuli essential for inhibitory learning and habituation, resulting in a reduction of fear in real-world contexts (Ørskov *et al*., 2022).

THEORETICAL IMPLICATIONS AND MECHANISMS

Our findings confirm VRET's effectiveness, thereby validating the fundamental principles of exposure therapy in a virtual context. The substantial effect sizes indicate that learning in virtual reality generalises effectively, aligning with the principles of stimulus generalisation theory. The comparable efficacy of VR and in vivo exposure indicates that therapeutic change is contingent more upon confronting fear and cognitive processing than on the physical realism of stimuli. Inhibitory learning could be especially pertinent: VR lets you safely experience many different fear elements over and over again (like heights and open spaces in a flight simulator), which could make non-fear associations stronger more quickly than some real-world experiences. Furthermore, VR frequently reduces "escape behaviours"; this implies that patients cannot literally run, which may support learning. Similarly, cognitive reappraisal is another mechanism; many VR protocols incorporate psychoeducation or cognitive tasks, assisting patients in reinterpreting cues as noted by Anderson *et al*. (2013) and Price and Anderson (2012), where cognitive CBT components were constant across VR/IVET. However, future research could measure mediators like expectancy violation and self-efficacy to clarify these pathways.

CLINICAL IMPLICATIONS

For practitioners, our results underscore VRET's viability. VRET solved many logistical challenges of in vivo therapy, such as bringing spiders into the clinic and recreating flight experiences, which can be more engaging for patients. Additionally, when live exposure is infeasible or the patient prefers VR, therapists may opt for VRET due to its comparable efficacy. Furthermore, VR also standardises exposure, enhancing fidelity across therapists and sites. In terms of guidelines, these findings support inclusion of VRET as an evidence-based treatment for anxiety, especially phobias and SAD. Mental health services could invest in VR systems as adjuncts to CBT. Notably, some studies indicate that brief, one-session VRET (such as a single 3–5-hour session for spider phobia) can yield lasting improvements, indicating cost-effective models are possible. On the other hand, clinicians should be mindful of limitations, though, as VR may not be appropriate for many patients (such as those with severe motion sickness) and requires training. In addition, given publication bias concerns, therapists should monitor progress closely and adjust as needed. For social anxiety, the slightly smaller effects of VRET relative to IVET in some analyses indicated that VR may need to be combined with cognitive techniques to match full CBT.

LIMITATIONS

There are limitations in our reviews. First, despite a thorough search, unpublished negative trials may have been missed, and many studies had small samples, which inflated effect estimates. We limited ourselves to English-language publications, which may have resulted in data omissions. Heterogeneity was high; we pooled diverse anxiety types, which may obscure disorder-specific nuances. Our effect-size calculations assume comparable outcomes across different scales, which is a limitation of meta-analysis. Additionally, the risk of bias within studies was not consistently low: some trials relied on self-report, had significant attrition, or had insufficient blinding, all of which raised bias risk. Finally, since most data are short-term (post-treatment), we can only infer durability; few trials had 6–12-month follow-ups. Thus, our conclusions should be seen as contingent on current, mostly short-term evidence.

FUTURE RESEARCH DIRECTIONS

To support the evidence base, larger, preregistered RCTs are required, especially for underrepresented conditions such as panic disorder, agoraphobia, PTSD, and children. Additionally, comparative trials should include active therapist involvement versus fully automated VR to determine essential ingredients. Furthermore, research should also focus on mechanisms like neural correlates of VR exposure using imaging and on optimising VR content, such as tailoring scenarios to individual fear profiles. It is necessary for longitudinal studies to evaluate if initial gains persist and transfer to real-life functioning, while cost-effectiveness analyses will inform adoption. Lastly, as VR technology evolves, such as more immersive "CAVE" systems and haptic feedback, trials should test whether these innovations enhance outcomes.

VI. CONCLUSION

The current evidence strongly supports VR-based exposure therapy as an effective treatment for anxiety disorders, especially specific phobias and social anxiety. VRET produces large reductions in fear, comparable to conventional exposure. It offers a viable avenue to expand access to evidence-based therapy through immersive, engaging digital interventions. Therefore, ongoing studies should refine these treatments and extend them to wider populations and anxiety subtypes. Overall, with continued development, VR exposure therapy may become a mainstream component of mental health care.

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