Journal of Behavioral and Cognitive Therapy 100524

Available online at ScienceDirect www.sciencedirect.com

Elsevier Masson France EM|consulte www.em-consulte.com/en

RESEARCH PAPER

Examining the comparative effectiveness of virtual reality and in-vivo exposure therapy on social anxiety and specific phobia: A systematic review & meta-analysis

Damla Kuleli [b], Philip Tyson [a], Nyle H. Davies [a], Biao Zeng [a,*]

[a] *Faculty of Life Science and Education, University of South Wales, Treforest Campus, Pontypridd, CF37 1DL, Wales, United Kingdom*
[b] *Faculty of Science and Technology, Bournemouth University, Fern Barrow, Poole, Dorset, BH12 5BB, United Kingdom*

Received 22 August 2024; received in revised form 3 February 2025; accepted 14 February 2025

KEYWORDS
Virtual reality;
In-vivo;
Exposure therapy;
Anxiety;
Phobia;
Meta-analysis

Abstract
Background: Virtual Reality Exposure Therapy (VRET) is the most widely used Virtual Reality psychotherapeutic intervention. There is empirical evidence supporting the effectiveness of VRET on Specific Phobia and Social Anxiety Disorder. Since it has an advantage over in-vivo Exposure Therapy (IVET) in being cost-effective, adaptable and controllable, previous studies suggest it is a suitable alternative psychotherapeutic intervention for IVET. However, there is a need for a meta-analysis to compare the effectiveness of VRET and IVET.
Aim: The present meta-analysis aimed to examine the effectiveness of VRET and IVET in the treatment of social anxiety disorder and specific phobia.
Methods: Eligible studies needed to be randomised controlled trials which included adults diagnosed with social anxiety or specific phobia according to the DSM-4 and DSM-5 or ICD 10. Studies needed to include two treatment conditions, VRET (using a head-mounted display) and IVET, and these should be accompanied by an additional control condition. Studies also needed to include pre-and post-assessment measures to allow for the calculation of effect size estimates. The electronic databases, PubMed, PsycNet, ProQuest and ScienceDirect were systematically searched for the relevant randomised controlled studies.
Data collection and results: A random effects meta-analysis was conducted to examine the comparable effectiveness of VRET and IVET on symptomology. The analysis suggested that both

* Corresponding author.
E-mail addresses: dkuleli@bournemouth.ac.uk (D. Kuleli), Philip.tyson@southwales.ac.uk (P. Tyson), nyle.davies@southwales.ac.uk (N. H. Davies), biao.zeng@southwales.ac.uk (B. Zeng).

https://doi.org/10.1016/j.jbct.2025.100524

are equally effective at reducing social phobia and anxiety symptoms with both approaches reporting moderate effect sizes.

Conclusions: Results of the meta-analysis demonstrate that VRET generates positive outcomes in the treatment of Specific Phobia and Social Anxiety Disorders which are comparable to IVET. However, due to the limited nature of the literature examined it is not possible to identify which approach is optimal.

Introduction

A specific phobia describes an intense and immediate fear or anxiety about a specific object or situation (APA, 2013), and has a cross-national lifetime prevalence of 7.4% with rates differing dependent on the type of specific phobia, as well as on geographic and socioeconomic factors (Kessler et al., 2005; Wardenaar et al., 2017; Grenier et al., 2011). In addition, the prevalence of a specific phobia is higher for females, a finding that is consistent across the world (Eaton, Bienvenu, & Miloyan, 2018; Kessler et al., 2005; Wardenaar et al., 2017; Stinson et al., 2007). Approximately 75% of those with this condition have multiple specific phobias (APA, 2013), and they do tend to last a lifetime (Kessler et al., 2005; Barlow, 2002). Impairment in functioning is also a consequence of specific phobia, with 18.7% of individuals reporting problems with home management, ability to work, relationships and social life (Wardenaar et al., 2017). Social Anxiety Disorder, sometimes termed Social Phobia, is a related form of intense anxiety where individuals experience fear of embarrassment or humiliation in social situations (APA, 2013). Sufferers believe that they will be negatively evaluated by others, and the distress causes a physiological reaction (Stein and Stein, 2008), and often results in impairments in academic and professional functioning because such individuals avoid social engagement (Freeman & Power, 2007). Social anxiety disorder is one of the most common anxiety disorders with a lifetime prevalence of 12.1% (Kessler et al., 2005; NICE, 2022). Women are more likely to develop social anxiety disorder compared to men (Asher & Aderka, 2018; Fehm, Pelissolo, Furmark, & Wittchen, 2005).

Evidence-based psychological interventions are the initial treatments offered for anxiety disorders and are preferred to psychopharmacology (NICE, 2014). The first choice psychological intervention for specific phobia and social anxiety disorder for adults, children and young people is cognitive behavioural therapy (CBT) based on Clark and Wells or Heimberg's model (Clark & Wells, 1995; Heimberg, Brozovich, & Rapee, 2014; NICE, 2013). CBT aims to change individuals' maladaptive cognitions and behavioural patterns using cognitive and behavioural strategies (Association, 2017). Exposure therapy is an empirically based behavioural treatment which is often used in combination with cognitive strategies as part of CBT, although it can be implemented alone for the treatment of specific phobia and social anxiety disorders (NICE, 2014). Other key aspects of a behavioural intervention include habituation and desensitisation. Habituation describes repeated exposure to the feared stimuli, which facilitates the development of coping skills and anxiety reduction. Desensitisation describes the pairing of the feared stimuli with a relaxation state, thus reducing anxiety (NICE, 2014).

There have been several meta-analyses into the effectiveness of CBT and exposure therapy for the treatment of specific phobia and social anxiety disorders. Wolitzky-Taylor, Horowitz, Powers, and Telch (2008) reported that for the treatment of specific phobia, there is a large overall effect size of exposure therapy compared with wait-list control conditions and a medium overall effect size of exposure therapy compared with placebo conditions. Additionally, when exposure therapy and non-exposure therapy were compared, there was a more significant reduction in anxiety symptoms for patients in the exposure therapy condition at post-treatment and follow-up (Wolitzky-Taylor et al., 2008). For the treatment of social anxiety disorder, a meta-analysis comparing CBT with exposure therapy and a placebo-control group resulted in a medium effect size favouring CBT (Hofmann & Smits, 2008). Another meta-analysis comparing pre-treatment and post-treatment measures has stated a large effect size of CBT and exposure therapy for the treatment of social anxiety disorder (Stewart & Chambless, 2009). Another meta-analysis reported that solely implementing a cognitive restructuring technique as part of CBT resulted in a large effect size; however, when combined with exposure techniques the effect size was even greater (Norton & Price, 2007).

Exposure therapy is based on Emotional Processing Theory (Foa & Kozak, 1986) which suggests that pathological fears are typified by dysfunctional cognitions about the threat posed by the stimulus, and the fear is maintained because of avoidance of the stimulus. For the treatment of specific phobia and social anxiety disorder, exposure therapy aims to alter the pathological fear structure by breaking the pattern between fear and avoidance behaviour by exposing individuals to the feared stimuli in a safe environment. This will permit developing coping mechanisms and learning more appropriate stimulus — response behaviours (Kaczkurkin & Foa, 2015).

There are different methods of delivering exposure therapy, such as imaginal exposure (vividly imagining the feared object or situation), interoceptive exposure (recreating the feared physical sensations), in-vivo exposure and virtual reality exposure (American Psychiatric Association, 2017). In in-vivo exposure therapy (IVET), patients are exposed to feared stimuli in real life (American Psychiatric Association, 2017). Virtual reality exposure therapy (VRET) is a relatively new form of exposure therapy and has a sim-

ilar rationale to in-vivo exposure therapy. However, instead of exposure to a real-life environment, a computer-generated virtual environment and stimuli are presented to the clients in a contextually relevant setting. The aim of using virtual reality (VR) in psychological applications is to provide a tool to build necessary skills which can then be transferred and implemented into the real world (Caponnetto, Triscari, Maglia, & Quattropani, 2021). VRET can be used as a stand-alone treatment or integrated into CBT (Arnfred et al., 2022).

Over the past three decades, virtual reality (VR) has found extensive application in various clinical conditions, including anxiety, PTSD, substance abuse, pain and post-stroke rehabilitation. Research primarily emphasizes the effectiveness and acceptance of VR rather than exploring the mechanisms behind these outcomes, which may vary by condition. For instance, using VR in post-stroke motor rehabilitation has established connections with mirror neurons, supported by neuroscientific evidence. However, the translation of the mirror neuron hypothesis to virtual exposure therapy (VRET) or immersive virtual exposure therapy (IVET) remains under-explored in terms of behavioral and biological evidence. Current empirical studies and meta-analyses indicate a consensus that both VRET and IVET have significantly lower anxiety levels. There may be shared theoretical frameworks between the two intervention techniques. Recently, Scheveneels, Engelhard, and Meyerbröker (2024) reviewed and compared three theories to elucidate VRET's effectiveness: inhibitory learning (expectancy violation), emotional processing (habituation), and self-efficacy. Further evidence is needed to determine the most appropriate theoretical basis.

There are several advantages of VRET over IVET. Firstly, clients prefer it; 76% of those surveyed said they preferred VRET over IVET, and there is a much lower refusal rate for VRET (3%) than IVET (27%: Garcia-Palacios, Hoffman, See, Tsai, & Botella, 2001). Secondly, VRET is both cost-effective and time-effective over IVET. Thirdly, there is a high level of control over stimuli in VRET; therefore, the application of VRET is safer and more convenient, and it is more flexible to individualise and customise to specific client-based situations. Fourthly, in VRET, exposure to the preferred stimuli can be repeated as much as needed; therefore, it can be said that VRET is less resource-intensive compared with IVET (Arnfred et al., 2022). For example, in IVET, gathering people for public speaking anxiety, bringing an animal to a session room for animal phobia, or arranging a flight for flight phobia requires more personal and physical resources than conducting these in the VR environment (Wechsler, Kümpers, & Mühlberger, 2019; van Loenen, Scholten, Muntingh, Smit, & Batelaan, 2022). Finally, VRET decreases the potential for an aversive response from the clients because the challenging situation can be speedily withdrawn (Arnfred et al., 2022). Nevertheless, there are some limitations with VRET, such as an uncomfortable sense of disembodiment, nausea/ motion sickness complications with the VR device, visual difficulties, and discomfort in communication with the therapist (Benbow & Anderson, 2019).

Several previous meta-analyses have investigated the effectiveness of VRET and compared it to IVET for anxiety disorders, including specific phobia and social anxiety disorder. The results of such studies have been varied, although many have reported no statistically significant difference between the treatments (Carl et al., 2019 (g = −0.07, 95% CI: −0.28 to 0.15); van Loenen et al., 2022 (g = 0.083, 95% CI − 0.13 to 0.30; p = 0.45); Opris et al., 2012 (D = 5 0.03, VAR D = 5 0.07, 95% CI 0.22 to 0.14, p > 0.05); Powers & Emmelkamp, 2008 (g = 0.34, 95% CI 0.05 to 0.63); Chesham, Malouff, & Schutte, 2018 (g = −0.01, 95% CI −0.30 to 0.28, p = 0.955; Horigome et al., 2020 (g = 0.07, 95% CI −0.41 to 0.55, p = 0.78); Fodor et al., 2018 (g = −0.02, 95% CI −0.14 to 0.1); van Loenen et al., 2022 (g = 0.083, 95% CI −0.13 to 0.30; p = 0.45); Wechsler et al., 2019 (g = −0.20, 95% CI −0.55 to 0.16, p = 0.271);. However, one meta-analyses favoured VRET over IVET (Cardos, David, & David, 2017 (g = 0.353, 95% CI 0.152 to 0.555, p = 0.01), whilst another reported IVET to be superior to VRET (Reeves, Curran, Gleeson, & Hanna, 2022).

However, there are limitations with many of the previous meta-analyses. Four of the previous reviews did not include the quality or risk of bias assessment (Carl et al., 2019; Opris et al., 2012; Parsons & Rizzo, 2008; Powers & Emmelkamp, 2008). Three did not report the test of heterogeneity (Opris et al., 2012; Wechsler et al., 2019; Powers & Emmelkamp, 2008) and of the ones that did report these data characteristics, there was substantial heterogeneity and evidence for small study effects (Fodor et al., 2018). In addition, five of the previous meta-analyses did not report the inclusion criteria for having a DSM or ICD diagnosis of specific phobia or social anxiety disorder, which limits their generalizability to clinical populations (Carl et al., 2019; Fodor et al., 2018; Parsons & Rizzo, 2008; Powers & Emmelkamp, 2008; Opris et al., 2012). Moreover, most of the previous meta-analyses have compared VRET with different active treatment conditions besides IVET or compared VRET with only WL control conditions or passive control conditions, or analysed the effectiveness of VRET with pre- treatment and post-treatment measures. Although there is a VRET and IVET comparison in previous meta-analyses, there are no previous meta-analyses which have examined RCTs comparing VRET and IVET alongside a control. Since previous meta- analyses have mostly included studies either with an active or inactive comparison condition; the present meta-analyses aimed to include studies that have both an active comparison condition (in the form of IVET) and a passive comparison condition which is any form of control condition. The present meta- analysis had a strict inclusion criterion to focus on comparing VRET and IVET and control conditions to eliminate potential confounding variables. Since there are several studies which have considered the effectiveness of VRET on specific phobia and social anxiety disorder compared with other anxiety disorders, the present meta-analysis specifically focuses on specific phobia and social anxiety disorder.

The main objective of this meta-analysis is to evaluate the effectiveness of VRET in comparison to IVET and control conditions for the treatment of specific phobia and social anxiety disorder. This review aims to examine (1) whether anxiety symptoms reduce after VRET, (2) whether anxiety symptoms reduce after IVET, and (3) if there is a difference between VRET and IVET in terms of treatment effectiveness as measured by pooled effect size.

Methods

Eligibility criteria

Studies needed to meet the following criteria to be eligible for inclusion; 1) population samples needed to be adult patients with a diagnosis of social anxiety disorder or specific phobia according to the DSM (4 or 5) or the ICD-10. 2) studies included both VRET and IVET interventions alongside a control condition. 3) studies included some level of random group allocation. 4) studies reported effect sizes or included enough detail to calculate effect sizes to facilitate meta-analysis. In addition to those outlined in the inclusion criteria, the excluded criteria comprised of 1) case studies, reviews, and study protocols, 2) not published in peer-reviewed journals, dissertations, or conference proceedings, and 3) published in a non-English language.

Information sources & searching Strategy

PubMed, Proquest, PsycNet and ScienceDirect were searched using predefined terms relating to social phobia treatment. Terms for interventions (such as but not limited to Virtual reality, VR, virtual reality exposure therapy, exposure therapy, and In-vivo exposure therapy) were combined with terms relating to social anxiety and specific phobias (such as but not limited to social anxiety disorder, specific phobia) were combined using the Boolean operator ''AND". Additionally, to ensure robust coverage of the literature, the reference lists of the retrieved articles and previous systematic reviews were also examined for relevant papers.

Selection

There were three reviewers in total (DK, BZ, and PT) and two authors independently reviewed each study. An inclusion checklist was created to ensure standardisation regarding study selection. When disagreements arose, the authors engaged in discussion until agreement was reached. Authors initially carried out title and abstracts screening follow by full text screening, concluding with data extraction and quality assessment. In cases of disagreement, the primary reviewers deliberated over the record until a consensus was reached. If they could not agree, the research team convened to assess the paper's suitability. This process involved evaluating the paper against the review inclusion checklist, systematically discussing each criterion, and determining how the contested paper satisfied them. The discussion continued until a consensus was achieved regarding the paper's status (Fig. 1).

Study risk of bias assessment

The quality of the included studies was assessed by the Cochrane Risk of Bias (RoB 2) tool (Higgins et al., 2019). Five domains of risk of bias were rated for the eight randomized controlled trials included in the meta-analysis, which included; selection bias, performance bias, attrition bias, detection bias, and reporting bias. For each study, the risk of bias was rated as low risk, high risk or unclear risk of bias.

Data extraction

The extraction form was derived from the Cochrane tool Li, Higgins, & Deeks, 2023 and steered the data extraction process. The tool collected data on the following areas: 1) record information (including authors and study aims); 2) Methodology (including participant characteristics, recruitment, study design and randomisation procedure); 3) Intervention (including number of sessions, duration of exposure and format of exposure and treatment context; 4) outcomes (including effect estimates, treatment mean scores and group size). Each record was initially extracted by author one and then second reviewed by either author two or three. Any disagreements were addressed in the same way as was outlined previously.

Synthesis methods

A random-effects model meta-analysis was conducted because the studies included were heterogeneous in terms of treatment duration, treatment context, sample size and gender proportion. The analysis was conducted in SPSS, focusing on the pooled effect sizes using Hedges'g due to small sample sizes of many of the included records. Two separate meta-analyses examined the effectiveness of the two included interventions (VRET & IVET) against a control group.

A heterogeneity test was conducted as part of the random-effects model meta-analysis. In the current study, heterogeneity was assessed and quantified using I^2, Tau^2 and H^2 indicates the percentage of total variation in the effect sizes across studies and was interpreted as follows: 25% - low heterogeneity, 50%- moderate heterogeneity, 75%- substantial heterogeneity (Higgins, Thompson, Deeks, & Altman, 2003). Tau^2 indicates the between-study variance. Low Tau^2 was interpreted as low variability across studies and high Tau^2 was interpreted as high variability across studies suggesting substantial heterogeneity. H^2 is another measurement of heterogeneity. H^2 = 1 indicates homogeneity (Higgins and Thompson, 2002). The funnel plot asymmetry and Egger' test was used to assess the presence of possible publication bias (Egger, Davey Smith, Schneider, & Minder, 1997).

Results

Eight studies fulfilled the eligibility criteria for the current meta-analysis (see Table 1). Included studies were published between 2000—2017 with the data from a total of 480 participants. All participants had been diagnosed with a specific phobia or social anxiety disorder according to the DSM or ICD. There were more female participants than male participants in all studies (Male = 28%, Female = 72%). The age range of participants for all studies was between 18 and 69.

Four of the studies were focused on social anxiety disorder, and four focused on specific phobia. Three specific phobia studies were about the fear of flying (Krijn et al., 2007; Rothbaum, Hodges, Smith, Lee, & Price, 2000; Rothbaum et al., 2006) and one concerned spider phobia

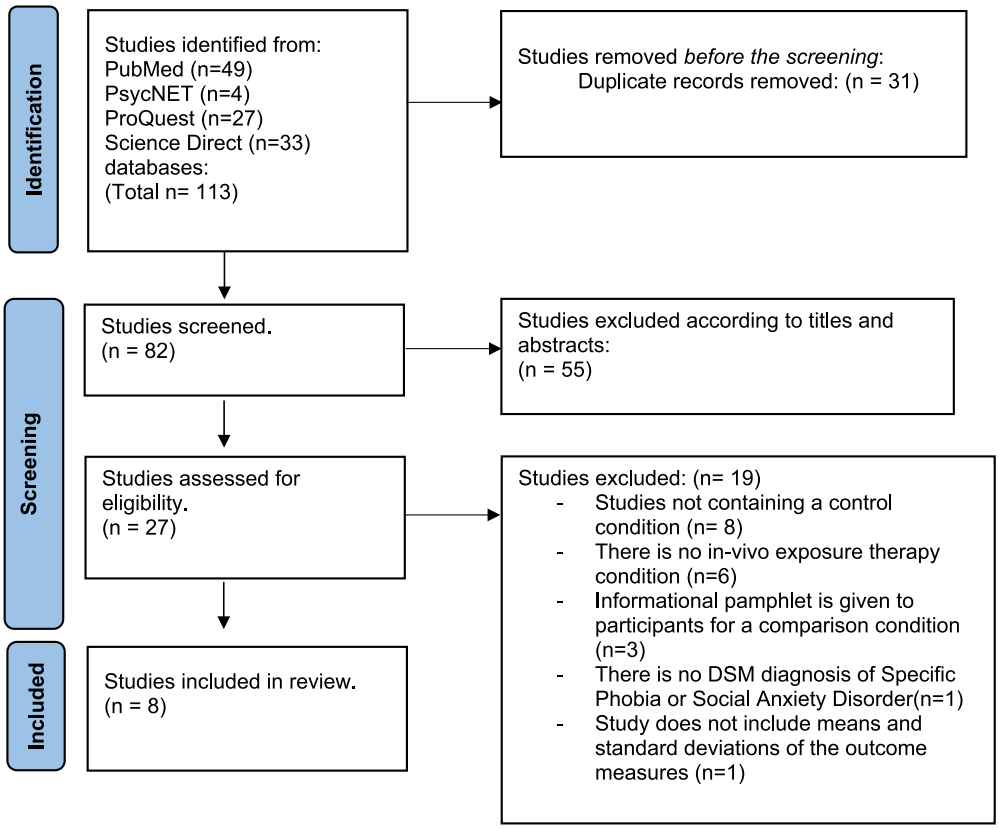

Fig. 1 PRISMA flow diagram for study selection.

(Michaliszyn, Marchand, Bouchard, Martel, & Poirier-Bisson, 2010).VRET utilized a head-mounted display (HMD) in all studies. All studies examined and compared the effectiveness of VRET, IVET, in relation to a control condition. For a complete overview of the pooled studies statistical outcomes see Table 2.

Random effect meta-analysis: Virtual reality exposure therapy

The meta-analytic model produced a pooled effect size of −0.789 (SE = −0.173, 95% CI: − 1.21 / − 036, P = 0.004), which suggests that VRET intervention did have a moderate effect in reducing anxiety scores. The confidence and aggregate confidence intervals were wide, indicating a lack of precision, which is also apparent in the standard errors for each study.

It was found that variation between the studies was low concerning true heterogeneity, with a Tau^2 of 0.1. When examining the total proportion of variance due to heterogeneity across the studies, it was found to be at 50% (indicated by the I^2 value of 0.50). H^2 also suggested a similar level of heterogeneity, with a value of 2.0 (Fig. 2 and Fig. 3).

The Egger's test was non-significant (see Table 3), indicating a lack of publication bias (p = 0.633), which was reflected in the Funnel plot (See Fig. 4). While there was no significant evidence of asymmetry, the analysis lacked large-sample studies.

Random effect meta-analysis in-vivo exposure therapy

The model produced a pooled effect size of −0.85 (SE = 0.10, 95% CI: −1.115/−0.590. P < 0.001), which suggests that IVET interventions did have a moderate effect in reducing anxiety scores. Like the VRET data, the IVET study's confidence and aggregate confidence intervals were wide, indicating a lack of precision. Additionally, in two studies (Rothbaum et al., 2000; Krijn et al., 2007), confidence intervals crossed zero indicating no effect. The heterogeneity across the sample was measured on the T^2 (0.00), H^2 (1.00) and I^2(0.00), all of which indicated a lack of meaningful heterogeneity. The low heterogeneity in the IVET meta-analysis likely reflects the standardized and systematic nature of IVET and the rigorous inclusion criteria of the review, whereas the higher heterogeneity in VRET is due to its more diverse and potentially less standardized approaches.

There was no significant evidence of asymmetry, but the analysis lacked large-sample studies. The Egger's test (see Table 4) was non-significant, indicating a lack of publication bias (p = 0.353), which was also reflected in the Funnel plot (see Fig. 5).

The meta-analyses indicate that both VRET and IVET are comparably effective, with both showing a moderate effect in reducing anxiety scores. However, given the nature of the present data, it is unclear which intervention approach is optimal. While our data suggest the two interventions are similarly effective, variations in methodology make direct comparisons challenging, highlighting the need for more

Table 1 Study characteristics.

References	Total N	Diagnosis (DSM or ICD)	Age M(SD) Age Range	Sex (m%, f%)	N of total sessions/ N of Exposure sessions	Duration of Exposure Therapy sessions	Exposure Format (Group Therapy/Individual Therapy)	Context of the Treatment
(1) Anderson et al. (2013)	97 (ITT)	Social Anxiety Disorder	39.03(11.26) 19–69 years	38.1%,61.9%	VRET/ IVET: 8 sessions/ VRET:4 IVET: 6	VRET: 30 min IVET: 20 min	VRET: Individual Therapy IVET: Group Therapy	VRET: CBT + VR Exposure IVET: CBT + In-vivo Exposure
(2) Bouchard et al. (2017)	59 (ITT)	Social Anxiety Disorder	34.5 (11.9) 18–65 years	27.1%,72.9%	VRET/ IVET: 14 sessions/ VRET/ IVET: 8 sessions	VRET/ IVET: 20–30 min	VRET: Individual Therapy IVET: Individual Therapy	VRET: CBT + VR Exposure IVET: CBT + In-vivo Exposure
(3) Kampmann et al. (2016)	60 (ITT)	Social Anxiety Disorder	36.9 18–65 years	36.7%,63.3%	VRET/ IVET: 10 sessions/ VRET/ IVET: 7 sessions	VRET/ IVET: 60 min	VRET: Individual Therapy IVET: Individual Therapy	VRET: VR exposure IVET: In-vivo Exposure
(4) Krijn et al. (2007)	59 (ITT)	Specific Phobia (Fear of Flying)	38.58 (10.91)	38.9%, 61.1%	VRET:4 sessions IVET: 2–4 sessions /N/A	VRET/ IVET: 60 min	VRET: Individual Therapy IVET: Individual Therapy	VRET: VR Exposure IVET: CBT + In-vivo Exposure
(5) Michaliszyn et al. (2010)	32 (ITT)	Specific Phobia (Spider Phobia)	29.1 (7.9) 18–51 years	3%, 97%	VRET/ IVET: 8 sessions/ VRET/ IVET: 6 sessions	VRET/ IVET: 90 min	VRET: Individual Therapy IVET: Individual Therapy	Psychoeducation, cognitive restructuring, relapse prevention + Gradual Exposure (IVET: In-vivo exposure, VRET: VR exposure)
(6) Robillard et al. (2010)	45 (ITT = Completers)	Social Anxiety Disorder	34.9 N/A	29%,71%	VRET/ IVET: 16 sessions/N/A	N/A	VRET: Individual Therapy IVET: Individual Therapy	VRET: CBT + VR Exposure IVET: CBT + In-vivo Exposure
(7) Rothbaum et al. (2000)	45 (Completers)	Specific Phobia (Fear of Flying)	40.5 (10.64) 24–69 years	29%, 71%	VRET/ IVET: 8 sessions/ VRET/ IVET: 4 sessions	VRET/ IVET: 60	VRET: Individual Therapy IVET: Individual Therapy	VRET: CBT + VR Exposure IVET: CBT + In-vivo Exposure
(8) Rothbaum et al. (2006)	83 (ITT)	Specific Phobia (Fear of Flying)	20.7%, 79.3% N/A	19.3%,80.7%	VRET/ IVET: 8 sessions/ VRET/ IVET: 4 sessions	N/A	VRET: Individual Therapy IVET: Individual Therapy	VRET: Anxiety management + VR Exposure IVET: Anxiety management + In-vivo Exposure

Table 2 Pre-treatment and post-treatment means, standard deviations and effect sizes of pre-post effects of VRET, in-vivo exposure for primary outcomes.

References	Primary Outcome Measure	N	VRET			N	IVET			Focus of the Study
			Pre (Mean (SD))	Post (Mean (SD))	Effect size (Hedges'g)		Pre (Mean (SD))	Post Mean (SD)	Effect size (Hedges' g)	
(1) Anderson et al. (2013)	PRCS	30	24.37 (2.54)	16.23 (7.61)	1.43	39	25.59 (2.59)	14.79 (8.53)	1.71	Social Anxiety Disorder
(2) Bouchard et al. (2017)	LSAS-SR	17	85.1 (29.5)	51.8 (23.3)	1.25	22	74.9 (24.5)	56.0 (26.9)	0.73	Social Anxiety Disorder
(3) Kampmann et al. (2016)	LSAS-SR	20	73.00 (17.25)	55.74 (18.65)	0.96	20	69.15 (19.44)	39.22 (25.01)	1.34	Social Anxiety Disorder
(4) Krijn et al. (2007)	FAS	30	65.30 (25.28)	53.28 (25.52)	0.47	23	67.57 (20.24)	57.91 (19.29)	0.49	Fear of Flying
(5) Michaliszyn et al. (2010)	FSQ-F	16	104.61(9.59)	54.37(22.46)	2.90	16	103.28(13.13)	47.88(14.07)	4.07	Spider Phobia
(6) Robillard et al. (2010)	LSAS	14	82.93 (32.23)	47.50 (17.83)	1.36	16	72.44 (23.91)	50.38 (23.87)	0.92	Social Anxiety Disorder
(7) Rothbaum et al. (2000)	FFI	15	105.85 (35.91)	86.14 (37.40)	0.54	15	133.30 (42.00)	87.53 (42.30)	1.09	Fear of Flying
(8) Rothbaum et al. (2006)	FFI	29	120.38 (44.24)	103.69 (49.35)	0.36	29	116.79 (57.74)	100.34 (43.49)	0.32	Fear of Flying

Note. VRET: Virtual Reality Exposure Therapy, IVET: In-vivo Exposure Therapy, PRCS: The Personal Report of Confidence as a Speaker, LSAS: Liebowitz Social Anxiety Scale, LSAS-SR: Liebowitz Social Anxiety Scale-Self Reported version, FAS: Flight Anxiety Situations Questionnaire, FSQ-F: Fear of Spiders Questionnaire, FFI: Fear of Flying Inventory, N/A: Not mentioned in the article.

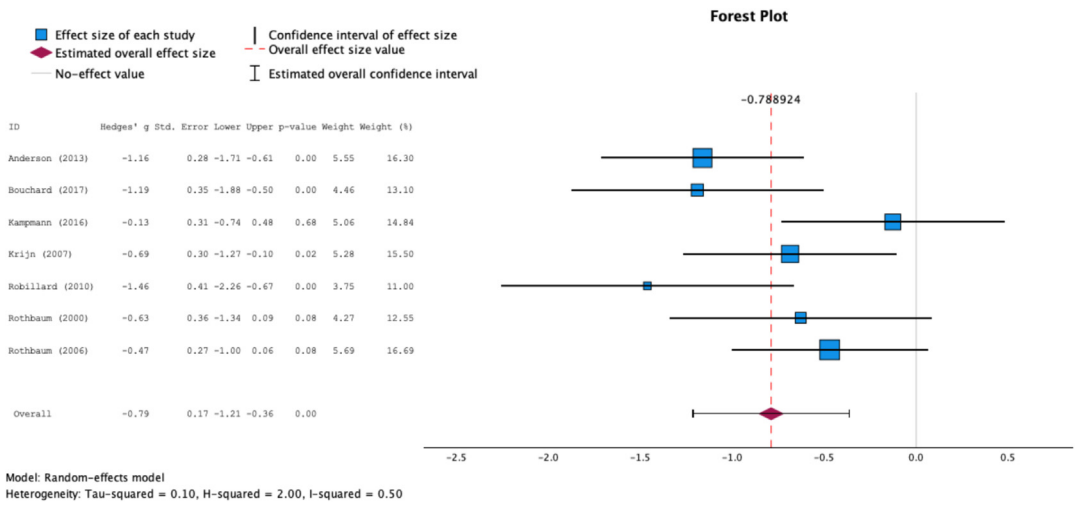

Fig. 2 Forest plot illustrating the pooled effect size of the VRET data.

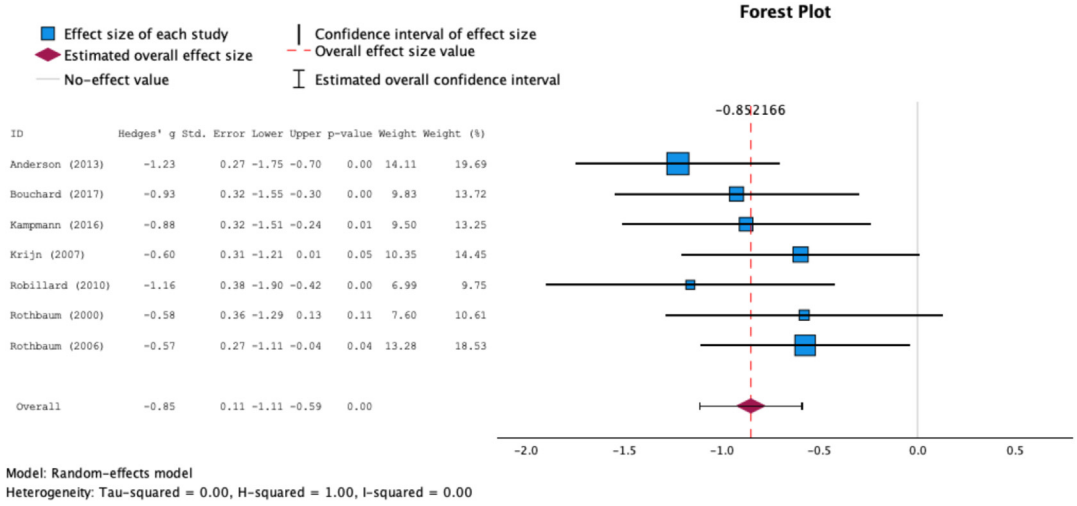

Fig. 3 Forest plot illustrating the pooled effect size of the IVET data.

Table 3 Egger's test for publication bias in the VRET data.

	Intercept	Confidence interval (95%)	t	p
Egger's test	0.633	−2.565: 3.830	0.509	0.633

robust studies to determine their relative effectiveness. Nevertheless, both appear to be similarly effective at addressing anxiety resulting from phobias.

Risk of bias in studies

Selection bias

All participants in these studies were randomly allocated to conditions, however, only three studies specifically explained the random sequence generation and allocation concealment and were therefore rated as ''Low risk" (see Table 5). Anderson et al. (2013) and Kampmann et al. (2016) stated that a simple randomization process was implemented using a computerized random number generator and a concealment procedure was implemented. Bouchard et al., 2017 indicated that a random assignment was generated with a random numbers table and assignments were concealed up to the first session. The remaining five studies did not specify the random sequence generation and allocation concealment were rated as ''Unclear".

Performance bias

None of the studies indicated the blinding of participants in the intervention allocation. Due to the nature of this type of research, it was not possible for participants, therapists or researchers to be unaware of their assigned intervention, so performance bias was rated as ''High risk" for all included studies.

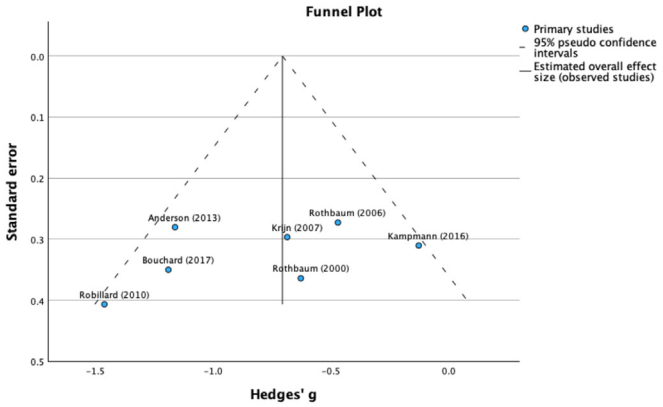

Fig. 4 Funnel plot illustrating the publication bias in the VRET data.

Table 4 Egger's test for publication bias in the IVET data.

	Intercept	Confidence interval (95%)	t	p
Egger's test	−0.998	−3.50/ 1.511	−1.023	0.353

Attrition bias

Studies reporting intent-to-treat data were mostly rated as ''Low risk" and five studies were rated as ''Low Risk" (Anderson et al., 2013; Bouchard et al., 2017; Kampman et al., 2016; Rothbaum et al., 2000; Rothbaum et al., 2006). Anderson et al. (2013) have indicated that there was no significant difference between dropout rates between the two intervention conditions and both intent-to-treat data and completers data results were reported in the study. In addition, the last observation carried forward (LOCF) was also performed to analyse missing data. Bouchard et al. (2017) also stated that intent-to-treat data was used and LOCF was conducted. Kampmann et al. (2016) specified that both completers' data and intent-to-treat data had been analysed and there was no significant difference between completers data and intent-to-treat data reported in the study. Rothbaum et al. (2006) stated that intent-to-treat data and Last Value Carried Forward were used to reduce the effect of missing data. Rothbaum et al. (2000) specified the reason for dropout and completers data was used and it is reported that dropout data is not significantly different from completers data. On the other hand, two studies were rated as ''High Risk" due to switching participants from one condition to another. Although Michaliszyn et al. (2010) et al. stated that intent to treat analysis was performed, participants in one treatment condition switched to another treatment condition due to not displaying reactions to the virtual spiders which resulted in a high risk of attrition bias. In addition, both Krijn et al. (2007) and Michaliszyn et al., 2010 reported that there was a reassignment of participants from waiting list condition to one of the treatment conditions and therefore these two studies were rated as ''High risk". Robillard, Bouchard, Dumoulin, Guitard, & Klinger, 2010) did not specify missing outcome data therefore it was rated as ''Unclear".

Detection bias

Anderson et al. (2013) and Kampmann et al. (2016) indicated that assessors were blind to the type of treatment the participants received. Since the primary outcome measures in the included studies were self-reported measurements, knowledge of the assigned intervention could

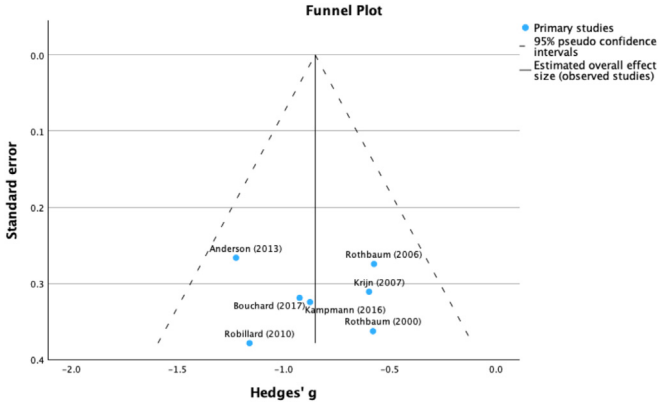

Fig. 5 Funnel plot illustration the publication bias in the IVET data.

Table 5 Individual risk of bias within the included studies.

Study	Risk of Bias arising from the Randomization Process (Selection Bias)		Risk of Bias arising from the Assignment to Interventions (Performance Bias)	Risk of Bias arising from the Missing Outcome Data (Attrition Bias)	Risk of Bias arising from the Measurement of the Outcome (Detection Bias)	Risk of Bias arising from the Selection of the Reported Results (Reporting Bias)
	Random Sequence Generation	Allocation Concealment				
Anderson et al. (2013)	Low	Low	High	Low	Low	Low
Bouchard et al. (2017)	Low	Low	High	Low	Unclear	Low
Kampmann et al. (2016)	Low	Low	High	Low	Low	Low
Krijn et al. (2007)	Unclear	Unclear	High	High	Unclear	Low
Michaliszyn et al. (2010)	Unclear	Unclear	High	High	Unclear	Low
Robillard et al. (2010)	Unclear	Unclear	High	Unclear	Unclear	Low
Rothbaum et al. (2000)	Unclear	Unclear	High	Low	Unclear	Low
Rothbaum et al. (2006)	Unclear	Unclear	High	Low	Unclear	Low

affect participants' outcome assessment. The other six studies did not specify the blinding of outcome assessors for selected primary outcome measures therefore they were rated as ''Unclear".

Reporting bias

Regarding reporting bias, all the studies were rated as ''Low risk" because all the planned outcome measures were reported in the studies. Overall, apart from the performance bias which can be tolerated for the nature of the study, most of the ratings of the studies were rated between low and unclear. Two studies were rated as ''High risk" for Attrition Bias.

Discussion

The present meta-analysis focused on the effectiveness of VRET and IVET and compared with each other in the treatment of Specific Phobia and Social Anxiety Disorder. Meta-analyses were conducted for VRET vs. control with their post-treatment primary outcome measures and compared with control group's outcome measures to examine whether they beneficially affected anxiety symptoms. According to our meta- analysis, VRET did have a moderate and significant mean overall effect size on symptoms of anxiety. This is consistent with previous meta-analyses, which have also stated that there is a large and significant overall mean effect favouring VRET compared to WL (Fodor et al., 2018; Carl et al., 2019; van Loenen et al., 2022; Opris et al., 2012; Powers & Emmelkamp, 2008). Furthermore, according to our meta- analysis, IVET did have a moderate and significant mean overall effect size on symptoms of anxiety with previous literature finding similar outcomes (Wolitzky-Taylor et al., 2008). Therefore, the current meta-analysis corresponds with previous meta-analytic research.

These results indicate that both VRET and IVET are effective in treating Specific Phobia and Social Anxiety Disorder and supports the findings of previous meta-analyses in reporting no statistically significant difference between VRET and IVET (Carl et al., 2019; van Loenen et al., 2022; Opris et al., 2012; Powers & Emmelkamp, 2008; Wechsler et al., 2019; Chesham et al., 2018; Horigome et al., 2020, Fodor et al., 2018; van Loenen et al., 2022; Wechsler et al., 2019). Since the results of this meta-analysis (and the wider literature) suggest that both VRET and IVET are effective in the reduction of anxiety symptoms for Specific Phobia and Social Anxiety Disorder, VRET can be considered as a suitable alternative psychotherapeutic intervention for the treatment of Specific Phobia and Social Anxiety Disorder. There are several advantages of VRET and with the promising results of the present meta-analysis, VRET should be used more in the field of clinical psychology to treat those with anxiety disorders. Indeed, clients prefer VRET over IVET (Garcia-Palacios et al., 2001).

However, there are several important methodological factors to be considered in relation to our findings. Firstly, there was variability in the delivery of the VRET treatment condition across studies, with several of these including VRET as part of a wider treatment regime. Specifically, only

two of the studies consisted of VR Exposure Therapy solely. Whilst in five of the studies, VRET conditions include VRET combined with CBT. In one of the studies, VRET conditions were combined with anxiety management. Based on this variability, it can be considered that there may be an internal validity problem whether the overall effectiveness of VRET is a result of VRET solely or a result of its combined effect with cognitive behavioural techniques. Secondly, while the outcomes of the review are valid based on the papers included, the actual pool of papers is small and by extension the overall evidence for and against the use of VRET is limited. As such, it is important to view these findings in a conservative manner and more evidence is required to provide a robust summary of the effectiveness of these interventions' modalities. Thirdly, issues with reporting were common. The risk of bias assessment of the current meta-analyses involves a significant amount of ''Unclear" risk of bias ratings. This indicates a meaningful issue with reporting common within the literature, with previous meta-analyses making the same observation.

Future research recommendations

This review has identified the need for experimentally rigorous, randomized controlled trials exploring the effectiveness of VRET. Future research should also focus on the effectiveness of VRET in comparison to IVET on specific disorders to examine which treatment model is best suited to each mental health condition. Considering that VRET has various advantages over IVET, there should be more studies to assess to what degree these advantages are generalized to clinical settings and how VRET can be used more frequently in a real clinical environment. Future studies should also explore how to enhance the effectiveness of VRET, e.g., might this be related to the immersiveness of the VR environment. Furthermore, there needs to be more research evaluating the efficacy of 'pure' VRET, i.e., not combined with other types of treatment. Additionally, for the effectiveness of VRET on anxiety disorders, it is important to evaluate how realistic the environment feels and its impact on the participants behavioural, physiological and cognitive responses.

Implications for clinical settings

VRET and IVET both have equal effects on the reduction of symptoms of anxiety; however, the benefits of VRET over IVET is that the former is; cost-effective, time-efficient, requiring less input from a professional, and can be tailored to individuals and situations. In addition, VR technology has become more convenient, affordable and available in recent years and is much more realistic than it used to be. Therefore, its potential to accurately portray a 'real-world' environment may enhance its therapeutic effectiveness. Nevertheless, the more the technology advances, new challenges will occur, and this will lead to an increasing necessity for the professional administering the treatment to be kept up to date with their training and skill set. Apart from this, it is known that nowadays VR devices are provided for patients to conduct self-led VR interventions and there is positive empirical evidence on the effectiveness of self-led VRET on anxiety disorders (Zainal, Chan, Saxena, Taylor, & Newman, 2021). With the proliferation of self-led VRET, people with limited access to therapists related either to their low socioeconomic status or not having access to therapists for different reasons can also get advantages from psychological treatments. Importantly, VRET has the potential to expand psychological treatment to many more people.

Limitations

This review had several limitations. Firstly, follow-up assessments were not included in the current meta-analysis, which does not allow an analysis of long-term outcomes. The review used a stringent inclusion criterion focusing on RCTs only which resulted in a small sample size. However, this was done to avoid the inclusion of papers of low methodological rigor. Indeed, most of the research examining the effectiveness of VRET has a study design that compares pre-treatment and post-treatment measures, whilst other studies compare VRET with control conditions such as WL, Imaginal Exposure, Relaxation Control, and Informational Pamphlets. None of them examined the comparison between VRET and IVET treatment conditions. Therefore, although this meta-analysis is small, it has significant value due to its focus.

Second, the time disparity between the papers included in the review should also be acknowledged, given the rapidly shifting pace at which VR technology improves. VR technology has developed since the 1950s and was first applied to treat phobias and other psychological disorders in the 1990s (Rothbaum et al., 1995). In the last three decades, VR applications have expanded widely. COVID-19 promoted an online intervention approach, and VR has been optimized to address this trend, given that face-to-face interventions are challenging during breakouts. Different VR technologies could impact VRET efficacy, Wrzus, Frenkel, and Schöne (2024) reviewed state-of-the-art immersive VR technology and highlighted opportunities, challenges and weaknesses for psychological research and application. As such, it is important to be mindful of the study's age when examining VR interventions, as older papers will be employing more rudimentary technologies, impacting the effectiveness of the intervention at large. Researchers should be mindful of this factor when examining VR interventions and be mindful of the type of technology being applied. By extension, researchers reporting such interventions should explicitly state the technology being used.

Thirdly, VRET shows considerable potential for managing anxiety disorders; however, practical factors must be addressed for its successful adoption in clinical settings. A key issue involves cost analysis, as the initial investment in VR hardware and software may be prohibitive, particularly for smaller practices (Freeman et al., 2017). Nevertheless, VRET could prove cost-effective by reducing the need for intensive therapist involvement and providing long-term therapeutic benefits. Therapist training constitutes another essential aspect of effective VRET implementation. Clinicians and therapists must attain competence in operating VR systems and delivering standardized protocols, with evi-

dence indicating that continuing education programs can enhance proficiency (Boeldt, McMahon, McFaul, & Greenleaf, 2019). Finally, patient acceptance of VR technology is crucial. While many patients exhibit positive attitudes toward VR, hesitancy remains among some due to unfamiliarity. Gradual introduction, educational initiatives, and personalized interventions are recommended to improve patient engagement and optimize the effectiveness of VRET (Glegg & Levac, 2018).

Integrating VRET into clinical practice presents several ethical and practical challenges that merit further discussion (Parsons, 2021). These include ensuring informed consent, maintaining data privacy, and addressing the potential for unintended psychological effects. Ethical training for practitioners is also essential to ensure the effective and ethical use of VRET. To facilitate scalability and acceptance, clear professional guidelines, such as those addressing privacy protocols and clinician competencies, should be established (Rizzo & Koenig, 2017). Additionally, there is a risk of technology dependence, where patients may become overly reliant on virtual environments rather than addressing underlying psychological issues. In addressing these challenges, the successful implementation and expansion of VRET in clinical settings can be more effectively achieved.

Conclusion

The current meta-analysis examined the effectiveness of VRET and IVET compared to WL control conditions. Results indicated that VRET is an equally effective alternative to IVET for treating Specific Phobia and Social Anxiety Disorder in decreasing anxiety symptoms. Indeed, there are several important advantages in using VRET over IVET, and patients prefer this new method of treatment. Furthermore, the use of VRET has the potential to expand the number of people who can be successfully treated for different types of anxiety disorders and potentially other mental health conditions.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

*Studies included in meta-analysis

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). https://doi.org/10.1176/appi.books.9780890425596.

American Psychiatric Association. What is Cognitive Behavioral Therapy?. *PTSD Guideline*. https://www.apa.org/ptsd-guideline/patients-and-families/cognitive-behavioral.pdf.

*Anderson, P. L., Price, M., Edwards, S. M., Obasaju, M. A., Schmertz, S. K., Zimand, E., & Calamaras, M. R. (2013). Virtual reality exposure therapy for social anxiety disorder: A randomized controlled trial. *Journal of Consulting and Clinical Psychology, 81*(5), 751–760. https://doi.org/10.1037/a0033559.

Arnfred, B., Bang, P., Hjorthøj, C., Christensen, C., Moeller, K., Hvenegaard, M., ... Nordentoft, M. (2022). Group cognitive behavioural therapy with virtual reality exposure versus group cognitive behavioural therapy with in vivo exposure for social anxiety disorder and agoraphobia: A protocol for a randomised clinical trial. *British Medical Journal, 12*. https://doi.org/10.1136/bmjopen-2021-051147 e051147.

Asher, M., & Aderka, I. M. (2018). Gender differences in social anxiety disorder. *Journal of clinical psychology, 74*(10), 1730–1741.

Barlow, D. H. (2002). *Anxiety and its disorders: The nature and treatment of anxiety and panic* ((2nd ed.).).

Benbow, A. A., & Anderson, P. L. (2019). A meta-analytic examination of attrition in virtual reality exposure therapy for anxiety disorders. *Journal of Anxiety Disorders, 61*, 18–26. https://doi.org/10.1016/j.janxdis.2018.06.006.

Boeldt, D., McMahon, E., McFaul, M., & Greenleaf, W. (2019). Using virtual reality exposure therapy to enhance treatment of anxiety disorders: Identifying areas of clinical adoption and potential obstacles. *Frontiers in Psychiatry, 10*, 773.

*Bouchard, S., Dumoulin, S., Robillard, G., Guitard, T., Klinger, É., Forget, H., ... Roucaut, F. X. (2017). Virtual reality compared with *in vivo* exposure in the treatment of social anxiety disorder: A three-arm randomised controlled trial. *The British Journal of Psychiatry, 210*(4), 276–283. https://doi.org/10.1192/bjp.bp.116.184234.

Caponnetto, P., Triscari, S., Maglia, M., & Quattropani, M. C. (2021). The simulation game-virtual reality therapy for the treatment of social anxiety disorder: A systematic review. *International Journal of Environmental Research and Public Health, 18*(24), 13209. https://doi.org/10.3390/ijerph182413209.

Cardos, R. A. I., David, O. A., & David, D. O. (2017). Virtual reality exposure therapy in flight anxiety: A quantitative meta-analysis. *Computers in Human Behavior, 72*, 371–380. https://doi.org/10.1016/j.chb.2017.03.007.

Carl, E., Stein, A. T., Levihn-Coon, A., Pogue, J. R., Rothbaum, B., Emmelkamp, P., ... Powers, M. B. (2019). Virtual reality exposure therapy for anxiety and related disorders: A meta-analysis of randomized controlled trials. *Journal of Anxiety Disorders, 61*, 27–36. https://doi.org/10.1016/j.janxdis.2018.08.003.

Chesham, R. K., Malouff, J. M., & Schutte, N. S. (2018). Meta-analysis of the efficacy of virtual reality exposure therapy for social anxiety. *Behaviour Change, 35*(3), 152–166. https://doi.org/10.1017/bec.2018.15.

Clark, D. M., & Wells, A. (1995). A cognitive model of social phobia. In R. G. Heimberg, M. R. Liebowitz, D. A. Hope, & F. R. Schneier (Eds.), *Social phobia: Diagnosis, assessment, and treatment* (pp. 69–93). The Guilford Press.

Eaton, W. W., Bienvenu, O. J., & Miloyan, B. (2018). Specific phobias. *The Lancet Psychiatry, 5*(8), 678–686. https://doi.org/10.1016/S2215-0366(18)30169-X.

Egger, M., Davey Smith, G., Schneider, M., & Minder, C. (1997). Bias in meta-analysis detected by a simple, graphical test. *The British Journal of Psychiatry (Clinical Research Ed.),, 315*(7109), 629–634. https://doi.org/10.1136/bmj.315.7109.629.

Fehm, L., Pelissolo, A., Furmark, T., & Wittchen, H. U. (2005). Size and burden of social phobia in Europe. *European neuropsychopharmacology: The Journal of the European College of Neuropsychopharmacology, 15*(4), 453–462. https://doi.org/10.1016/j.euroneuro.2005.04.002.

Foa, E. B., & Kozak, M. J. (1986). Emotional processing of fear: Exposure to corrective information. *Psychological Bulletin, 99*(1), 20–35. https://doi.org/10.1037/0033-2909.99.1.20.

Fodor, L. A., Cotet, C. D., Cuijpers, P., Szamoskozi, S., David, D., & Cristea, I. A. (2018). The effectiveness of virtual reality-based interventions for symptoms of anxiety and depression: A meta-analysis. *Scientific Reports, 8*(1), 10323. https://doi.org/10.1038/s41598-018-28113-6.

Freeman, C., & Power, M. (Eds.). (2007). *Handbook of evidence-based psychotherapies: A guide for research and practice*. John Wiley & Sons.

Freeman, D., Reeve, S., Robinson, A., Ehlers, A., Clark, D., Spanlang, B., & Slater, M. (2017). Virtual reality in the assessment, understanding, and treatment of mental health disorders. *Psychological Medicine, 47*(14), 2393–2400.

Garcia-Palacios, A., Hoffman, H. G., See, S. K., Tsai, A., & Botella, C. (2001). Redefining therapeutic success with virtual reality exposure therapy. *Cyberpsychology & Behavior: The Impact of the Internet, Multimedia and Virtual Reality on Behavior and Society, 4*(3), 341–348. https://doi.org/10.1089/109493101300210231.

Glegg, S. M. N., & Levac, D. E. (2018). Barriers, facilitators and interventions to support virtual reality implementation in rehabilitation: A scoping review. *PM&R, 10*(11), 1237–1251.

Grenier, S., Schuurmans, J., Goldfarb, M., Pre´ville, M., Boyer, R., O'Connor, K., ... Hudon, C. (2011). The epidemiology of specific phobia and subthreshold fear subtypes in a community-based sample of older adults. *Depression and Anxiety, 28*(6), 456–463. https://doi.org/10.1002/da.20812 (Scientific committee of the ESA study).

Higgins, J. P., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. *British Medical Journal (Clinical Research ed.),, 327*(7414), 557–560. https://doi.org/10.1136/bmj.327.7414.557.

Higgins, J. P., Savović, J., Page, M. J., Elbers, R. G., & Sterne, J. A. (2019). Assessing risk of bias in a randomized trial. *Cochrane handbook for systematic reviews of interventions*, 205–228.

Hofmann, S. G., & Smits, J. A. (2008). Cognitive-behavioral therapy for adult anxiety disorders: A meta-analysis of randomized placebo-controlled trials. *The Journal of Clinical Psychiatry, 69*(4), 621–632. https://doi.org/10.4088/jcp.v69n0415.

Horigome, T., Kurokawa, S., Sawada, K., Kudo, S., Shiga, K., Mimura, M., & Kishimoto, T. (2020). Virtual reality exposure therapy for social anxiety disorder: A systematic review and meta-analysis. *Psychological Medicine, 50*(15), 2487–2497. https://doi.org/10.1017/S0033291720003785.

Kaczkurkin, A. N., & Foa, E. B. (2015). Cognitive-behavioral therapy for anxiety disorders: An update on the empirical evidence. *Dialogues in Clinical Neuroscience, 17*(3), 337–346. https://doi.org/10.31887/DCNS.2015.17.3/akaczkurkin.

*Kampmann, I. L., Emmelkamp, P. M., Hartanto, D., Brinkman, W. P., Zijlstra, B. J., & Morina, N. (2016). Exposure to virtual social interactions in the treatment of social anxiety disorder: A randomized controlled trial. *Behaviour Research and Therapy, 77*, 147–156. https://doi.org/10.1016/j.brat.2015.12.016.

Kessler, R. C., Berglund, P., Demler, O., Jin, R., Merikangas, K. R., & Walters, E. E. (2005). Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the national comorbidity survey replication. *Archives of General Psychiatry, 62*(6), 593–602. https://doi.org/10.1001/archpsyc.62.6.593.

*Krijn, M., Emmelkamp, P. M., Olafsson, R. P., Bouwman, M., van Gerwen, L. J., Spinhoven, P., ... van der Mast, C. A. (2007). Fear of flying treatment methods: Virtual reality exposure vs. cognitive behavioral therapy. *Aviation, Space, and Environmental Medicine, 78*(2), 121–128.

Heimberg, R. C., Brozovich, F. A., & Rapee, R. M. (2014). A cognitive-behavioral model of social anxiety disorder. In S. G. Hofmann & P. M. DiBartolo (Eds.), *Social Anxiety: Clinical, Developmental, and Social Perspectives* (pp. 705–728). Elsevier Academic Press. https://doi.org/10.1016/B978-0-12-394427-6.00024-8.

Li, T., Higgins, J. P. T., Deeks, J. J. (Eds.). Chapter 5: Collecting data. In: J.P.T. Higgins, J. Thomas, J. Chandler, M. Cumpston, T. Li, M.J. Page, V.A. Welch (Eds.). Cochrane Handbook for Systematic Reviews of Interventions version 6.4 (updated August 2023). Cochrane, 2023. Available from http://www.training.cochrane.org/handbook.

*Michaliszyn, D., Marchand, A., Bouchard, S., Martel, M. O., & Poirier-Bisson, J. (2010). A randomized, controlled clinical trial of in virtuo and in vivo exposure for spider phobia. *Cyberpsychology, Behavior and Social Networking, 13*(6), 689–695. https://doi.org/10.1089/cyber.2009.0277.

National Institute for Health and Care Excellence (2013). Social anxiety disorder: recognition, assessment and treatment. https://www.nice.org.uk/guidance/cg159.

National Institute for Health and Care Excellence (2014). Anxiety disorders. https://www.nice.org.uk/guidance/qs53.

Norton, P. J., & Price, E. C. (2007). A meta-analytic review of adult cognitive-behavioral treatment outcome across the anxiety disorders. *The Journal of Nervous and Mental Disease, 195*(6), 521–531. https://doi.org/10.1097/01.nmd.0000253843.70149.9a.

Opris, D., Pintea, S., García-Palacios, A., Botella, C., Szamosközi, Ş., & David, D. (2012). Virtual reality exposure therapy in anxiety disorders: A quantitative meta-analysis. *Depression and Anxiety, 29*(2), 85–93. https://doi.org/10.1002/da.20910.

Parsons, T. D. (2021). Ethical challenges of using virtual environments in the assessment and treatment of psychopathological disorders. *Journal of Clinical Medicine, 10*(3), 378.

Parsons, T. D., & Rizzo, A. A. (2008). Affective outcomes of virtual reality exposure therapy for anxiety and specific phobias: A meta-analysis. *Journal of Behavior Therapy and Experimental Psychiatry, 39*(3), 250–261. https://doi.org/10.1016/j.jbtep.2007.07.007.

Powers, M. B., & Emmelkamp, P. M. (2008). Virtual reality exposure therapy for anxiety disorders: A meta-analysis. *Journal of Anxiety Disorders, 22*(3), 561–569. https://doi.org/10.1016/j.janxdis.2007.04.006.

Reeves, R., Curran, D., Gleeson, A., & Hanna, D. (2022). A meta-analysis of the efficacy of virtual reality and in vivo exposure therapy as psychological interventions for public speaking anxiety. *Behavior Modification, 46*(4), 937–965. https://doi.org/10.1177/0145445521991102.

Rizzo, A., & Koenig, S. T. (2017). Is clinical virtual reality ready for primetime? *Neuropsychology, 31*(8), 877.

*Robillard, G., Bouchard, S., Dumoulin, S., Guitard, T., & Klinger, E. (2010). Using virtual humans to alleviate social anxiety: Preliminary report from a comparative outcome study. *Studies in Health Technology and Informatics, 154*, 57–60.

Rothbaum, B. O., Hodges, L. F., Kooper, R., Opdyke, D., Williford, J. S., & North, M. (1995). Virtual reality graded exposure in the treatment of acrophobia: A case report. *Behavior therapy, 26*(3), 547–554.

*Rothbaum, B. O., Anderson, P., Zimand, E., Hodges, L., Lang, D., & Wilson, J. (2006). Virtual reality exposure therapy and standard (in vivo) exposure therapy in the treatment of fear of flying. *Behavior Therapy, 37*(1), 80–90. https://doi.org/10.1016/j.beth.2005.04.004.

*Rothbaum, B. O., Hodges, L., Smith, S., Lee, J. H., & Price, L. (2000). A controlled study of virtual reality exposure therapy for the fear of flying. *Journal of Consulting and Clinical Psychology, 68*(6), 1020–1026. https://doi.org/10.1037//0022-006x.68.6.1020.

Scheveneels, S., Engelhard, I., & Meyerbröker, K. (2024). Opening the Black Box: The underlying working mechanisms in virtual-reality exposure therapy for anxiety disorders. *Clinical Psychological Science* 21677026241267945.

Stein, M. B., & Stein, D. J. (2008). *Social anxiety disorder. The lancet, 371*(9618), 1115–1125.

Stewart, R. E., & Chambless, D. L. (2009). Cognitive-behavioral therapy for adult anxiety disorders in clinical practice: A meta-analysis of effectiveness studies. *Journal of Consulting and Clinical Psychology, 77*(4), 595–606. https://doi.org/10.1037/a0016032.

Stinson, F. S., Dawson, D. A., Patricia Chou, S., Smith, S., Goldstein, R. B., June Ruan, W., & Grant, B. F. (2007). The epidemiology of DSM-IV specific phobia in the USA: Results from the national epidemiologic survey on alcohol and related conditions. *Psychological Medicine, 37*(7), 1047–1059. https://doi.org/10.1017/S0033291707000086.

van Loenen, I., Scholten, W., Muntingh, A., Smit, J., & Batelaan, N. (2022). The effectiveness of virtual reality exposure-based cognitive behavioral therapy for severe anxiety disorders, obsessive-compulsive disorder, and posttraumatic stress disorder: Meta- analysis. *Journal of Medical Internet Research, 24*(2). https://doi.org/10.2196/26736 e26736.

Wardenaar, K. J., Lim, C., Al-Hamzawi, A. O., Alonso, J., Andrade, L. H., Benjet, C., ... de Jonge, P. (2017). The cross-national epidemiology of specific phobia in the world mental health surveys. *Psychological Medicine, 47*(10), 1744–1760. https://doi.org/10.1017/S0033291717000174.

Wechsler, T. F., Kümpers, F., & Mühlberger, A. (2019). Inferiority or even superiority of virtual reality exposure therapy in phobias?: A systematic review and quantitative meta- analysis on randomized controlled trials specifically comparing the efficacy of virtual reality exposure to gold atandard *in vivo* exposure in agoraphobia, specific phobia, and social phobia. *Frontiers in Psychology, 10*, 1758. https://doi.org/10.3389/fpsyg.2019.01758.

Wolitzky-Taylor, K. B., Horowitz, J. D., Powers, M. B., & Telch, M. J. (2008). Psychological approaches in the treatment of specific phobias: A meta-analysis. *Clinical Psychology Review, 28*(6), 1021–1037. https://doi.org/10.1016/j.cpr.2008.02.007.

Wrzus, C., Frenkel, M. O., & Schöne, B. (2024). Current opportunities and challenges of immersive virtual reality for psychological research and application. *Acta Psychologica, 249* 104485.

Zainal, N. H., Chan, W. W., Saxena, A. P., Taylor, C. B., & Newman, M. G. (2021). Pilot randomized trial of self-guided virtual reality exposure therapy for social anxiety disorder. *Behaviour Research and Therapy, 147*. https://doi.org/10.1016/j.brat.2021.103984 103984.