Treating Anxiety Disorders with VR-based Exposure Therapy- A Scoping Review

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Abstract

Research indicates that VRET is effective in treating anxiety disorders while mitigating many limitations of traditional exposure therapy. Yet, there are imbalances regarding the researched populations and anxiety disorders, and these imbalances persist in recent literature studies as well. In addition, recent technological advances might improve VRET effectiveness and availability. This scoping review aims to fill these research gaps by reviewing recent literature on the effectiveness of VRET to treat anxiety disorders. A search on the databases Scopus and PsycInfo resulted in selecting 20 relevant studies. From these, data points regarding their participant and study characteristics, as well as their usability, feasibility, and effectiveness were collected. Average sample size was 50.2 (mean age = 29.29, male/female ratio = 137:135). The main focus was on specific phobias and PTSD, particularly in soldiers with PTSD. Most of the studies were RCTs, but there were also single case experimental designs and feasibility studies. VRET was administered in sessions ranging from 4 to 29, with varying lengths, and was typically administered by a professional. The used VR-technology ranged from headsets, to including joysticks and vibration-eliciting platforms. Drop-out rates and levels of cybersickness varied among the studies, and VR was generally accepted by participants. VRET was found to improve anxiety disorder symptoms and other relevant measures such as anxiety and depression in most studies. However, some studies found that effectiveness was not different from control groups or other methods. The positive changes from VRET were generally maintained at follow-up measurements. This study suggests that VRET is effective in treating anxiety disorders. Yet, there are huge imbalances with regards to the studied anxiety disorders and populations which makes generalisations difficult. Future research should incorporate these less researched populations and anxiety disorders, and try to examine possible mediators which influence the effectiveness of VRET.

Keywords: Virtual reality, VRET, anxiety disorders, exposure therapy

Anxiety disorders are the most frequent mental illnesses in Europe, affecting around 61.5 million people (Wittchen et al., 2011). The current COVID-19 pandemic seems to additionally accelerate the symptoms and prevalence of these disorders (Yang et al., 2020). Therefore, cost-effective treatment interventions are amply needed.

Exposure therapy is one of the most effectful interventions for treating anxiety disorders and is based on confronting patients with the feared stimuli. This is usually done by either imagining the stimuli or being exposed to a real version of it which is called in vivo exposure (Bandelow et al., 2015). These two methods, however, contain several limitations. Imaginal exposure often lacks the needed immersion, while in vivo exposure might not be feasible or too costly and often lacks control mechanisms (Gorini & Riva, 2008; Maples-Keller et al., 2017).

To circumvent these limitations, Virtual Reality-based Exposure Therapy (VRET) might be applicable (Krijn et al., 2004; Maples-Keller et al., 2017; Powers & Emmelkamp, 2008). Recent literature studies add to the growing body of research attesting that VRET is effective in treating anxiety disorders (Deng et al., 2019; Kothgassner et al., 2019; Wechsler et al., 2019). Yet, these studies focus on one type of anxiety disorder, and therefore a comprehensive overview of VRET's effectiveness for all anxiety disorder types is missing. In addition, technological advances in VR are growing at a fast pace, with for example improving graphics and novel features, such as eye-tracking (Eira, 2023). This, in turn, might affect VRET effectiveness, and therefore it is important that literature reviews are up-to-date to account for these technological advances (Sygel & Wallinius, 2021). This scoping review aims to fill these research gaps by investigating and presenting current research related to VRET and anxiety disorders.

Anxiety Disorders & Common Treatment Methods

Patients with anxiety disorder suffer from heightened feelings of concern and dread. These are usually experienced for prolonged periods of time and are often accompanied by physical symptoms, such as an elevated heart beat or sleep problems (Gorini & Riva, 2008). To reduce symptoms or to achieve short term relief, patients frequently develop ritualised behaviour and strategies to avoid the feared stimuli or prevent the feared situation from occurring. These coping strategies often lead to additional problems, such as straining relationships or occupational conflicts (Gorini & Riva, 2008). In the DSM-5, several disorders are grouped together as anxiety-disorders, such as panic disorder, agoraphobia and specific phobia (Association, n.d.; Bandelow et al., 2022). Anxiety disorders are the most common mental health disorders in Europe (Wittchen et al., 2011), and the onset can already be in childhood and mostly occurs in patients who are younger than 30 years old. The disease's course is often chronic and frequently worsens with time without treatment (Bandelow et al., 2022; Gorini & Riva, 2008). Moreover, anxiety disorders often co-occur with other anxiety disorders and major depressions (Bandelow et al., 2022). Anxiety disorders also pose a huge societal burden, as patients suffering from anxiety disorders often require treatment, such as therapy and medication, which can add to healthcare costs. In addition, people with anxiety disorders may have difficulty performing well at work or in school, and might even miss work or school due to their symptoms. This can lead to decreased productivity and lost income for individuals, as well as increased costs for businesses and the economy as a whole (Gorini & Riva, 2008; Powers & Emmelkamp, 2008).

One common intervention to treat anxiety disorders is exposure therapy (Maples-Keller et al., 2017) which is an established intervention for various psychological disorders. For example, it has been labelled a "gold standard" to treat PTSD and is recommended as first-line treatment by many institutions (Rauch et al., 2012). With regards

to anxiety disorders, exposure therapy is regarded as one of the most effective evidence-based treatments methods (Deacon & Abramowitz, 2004; Maples-Keller et al., 2017; Nathan & Gorman, 2015), with in vivo exposure usually being even more effective than imaginative exposure (Parsons & Rizzo, 2008).

Exposure therapy is based on habituation, a process by which an individual's response to a stimulus decreases over time as a result of repeated exposure to that stimulus. During exposure therapy, an individual is repeatedly exposed to the feared stimulus in a safe and controlled environment, so that their brain starts to habituate to that stimulus. This means that over time, the individual's fear and anxiety in response to the stimulus will decrease, and they will become less sensitive to it. In other words, during exposure therapy patients experience that the dreaded stimulus is not dangerous and that there is no need to continue responding with fear and anxiety which then lessens the patient's symptoms (Gorini & Riva, 2008; Maples-Keller et al., 2017). Exposure to the feared stimuli usually happens gradually, so that patients are not overwhelmed. For example, someone who fears spiders might start by imagining touching a spider and then in subsequent sessions be exposed to a real spider (Gorini & Riva, 2008).

For all its advantages, however, exposure therapy still has several limitations. Patients often feel reluctant to be exposed "to the real phobic stimulus or situation" and even if they do, in vivo exposure bears the risk of being too intense, as therapists often have limited control over the strength or duration of the stimuli patients are exposed to (Gorini & Riva, 2008). Additionally, providing the feared stimuli or seeking the necessary environment is often not feasible for cost or time related reasons, for example boarding an aeroplane to treat fear of flying (Gorini & Riva, 2008). On the other hand, exposure therapy based on imagination alone is dependent on the patient's ability to sufficiently imagine the dreaded situation and usually lacks the necessary impact (Maples-Keller et al., 2017).

VR-based Exposure Therapy

One approach to overcome the disadvantages of common exposure-therapy is to incorporate VR in the therapy process. VR "is a technological interface that allows users to experience computer generated environments within a controlled setting" and might utilise technological devices, such as body trackers and touch-sensitive gloves (Maples-Keller et al., 2017). Thereby, VR aims to provide users with a naturalistic and immersive experience in a digital environment in which they can actively participate (Gorini & Riva, 2008; Powers & Emmelkamp, 2008).

VRET mitigates many of the limitations of conventional exposure therapy. It allows for exposure in settings which would be too costly or not logistically feasible in vivo, such as simulating being on an aeroplane, and also addresses the problem that clients need to imagine the stimuli. Furthermore, therapists have greater means of control through which they can adjust the intensity and frequency of the stimuli, something which is harder to achieve with a real stimuli (Gorini & Riva, 2008; Maples-Keller et al., 2017; Powers & Emmelkamp, 2008). All of these advantages increase the chances that patients seek out and complete therapy, as studies indicate that many participants prefer VRET over in vivo exposure therapy (Garcia-Palacios et al., 2001), that VRET shows increased compliance rates (Meindl et al., 2019), and that VRET shows lower drop-out rates than traditional CBT (Castro et al., 2014). Thus, VRET might be a serious alternative to real life exposure therapy.

There are many literature reviews examining the vast amount of research dedicated to VRET (Krijn et al., 2004; Maples-Keller et al., 2017; Powers & Emmelkamp, 2008), indicating that VRET can indeed be an effective alternative to in vivo exposure therapy for treating anxiety disorders. In the last few years, several cited literature reviews have been conducted (Deng et al., 2019; Kothgassner et al., 2019; Wechsler et al., 2019). These indicate that VRET is as effective as in vivo exposure for treating PTSD, however, they also note that

most studies focus on a specific population suffering from PTSD, namely male veterans with combat-related PTSD (Deng et al., 2019; Kothgassner et al., 2019). Furthermore, VRET seems to be as effective as in vivo exposure for treating Specific Phobias and Agoraphobia (Wechsler et al., 2019). For Social Phobias, however, the effect sizes seem to differ considerably across studies, showing no clear indication that VRET is equivalent to in vivo exposure. Rather, it might be used alongside more traditional cognitive interventions (Wechsler et al., 2019).

Current Study

Recent reviews usually focused on VRET in relation to a specific anxiety disorder, such as PTSD (Deng et al., 2019; Kothgassner et al., 2019) or phobias (Wechsler et al., 2019). Thus, a general overview of recent literature concerning all anxiety disorders is missing. Furthermore, VR is a rapidly developing technology. For example, devices with better graphics and new features, such as eye-tracking are becoming widely available (Eira, 2023), and these technical advances might improve treatment outcomes. Likewise, the increased affordability of VR-technology (Boeldt et al., 2019; Eira, 2023) might increase the amount of conducted studies in this domain. Therefore, time intervals between literature reviews should be appropriately short as well (Sygel & Wallinius, 2021). This study is a scoping review which tries to fill these research gaps by reviewing the current literature related to treating anxiety disorders with VRET.

This scoping review is updating the literature to the latest findings regarding VRET intervention studies which aim to reduce anxiety disorder symptoms and which have been conducted in the last three years, ergo since 2019. The following research questions are formulated, to further define the scope of this review:

1. What are the population characteristics of the studies investigating the treatment of anxiety disorders with VRE?

2. What are the study characteristics of the studies investigating the treatment of anxiety disorders with VRE?
3. What is the perceived feasibility and usability of the interventions used to treat anxiety disorders with VRET, as rated by participants?
4. What outcome measures are used in intervention studies that are aimed at examining the effectiveness of VRET interventions for the treatment of anxiety?
5. How effective is the intervention in treating anxiety disorders with VRE?

Methods

Research Design

The research design of this study is a scoping review. In general, scoping reviews explore and present evidence related to a certain research topic. They are "explorative and descriptive in nature" and they have rather broad research questions, especially when compared to systematic reviews (Peters et al., 2020). While systematic reviews are useful to aid clinical-decision making, scoping reviews are useful to evaluate and interpret research in an emerging field, such as VRET in the case of this study. One of the recommended guidelines for conducting scoping reviews is the PRISMA-ScR (Peters et al., 2020; Tricco et al., 2018) which this study will follow.

Search Strategy

To find relevant studies for this scoping review, the databases PsycInfo and Scopus were used. These databases are chosen because they focus on psychological and medical topics, and because they are utilised in other scoping-reviews at the intersection of technology and psychology (van Lotringen et al., 2021).

The search was conducted on 30th September, 2022. The following search-terms terms were used when querying the databases: '(anxiety disorders OR anxiety OR phobia OR PTSD OR Agoraphobia) AND (VR OR Virtual Reality OR VRET OR VRET OR Virtual

Reality Exposure Therapy OR VR based exposure therapy)'. These search-terms can appear either in the title, abstract or keywords of the articles.

Eligibility Criteria

The following criteria were used to include literature for this study:

Inclusion Criteria:

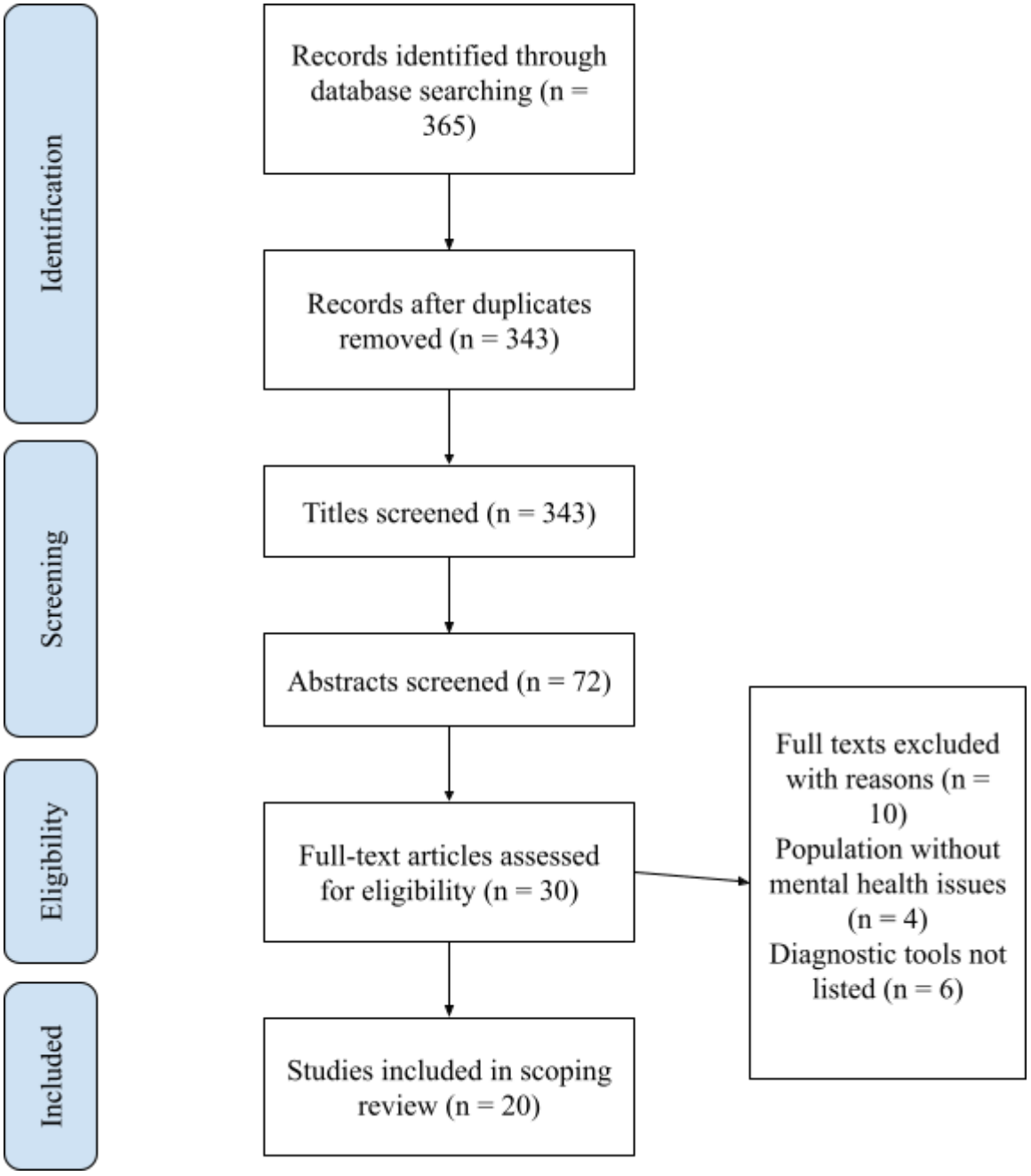
1. The article encompasses original quantitative research which was published in a peer-reviewed journal.
2. The article was written in English.
3. The article was published in 2019 or later.
4. The article investigated VRET to treat anxiety disorders. Thus, VRET has to be used in at least one treatment condition.
5. The article includes a sample of people that have an anxiety disorder according to DSM-4, DSM-5 or ICD criteria.
6. The article used a measure to assess the effectiveness of treating anxiety disorders with VRET. Thus, research which is only concerned with the usability of VRET for treating anxiety disorders will be excluded.

Study Selections

Studies found in the search were then further selected by one researcher and according to the following process: First, the title was screened. Secondly, the abstract was screened. Thirdly, the whole article was assessed by the author of this study and based on the inclusion criteria, found to be suitable for this study or not. The study selection process and its results are shown in Figure 1 which is based on the PRISMA-ScR guidelines (Peters et al., 2020).

Figure 1

Flowchart of the Inclusion and Exclusion Progress of Articles for the Scoping Review.



Data Extraction

The articles investigated in this scoping-review were examined based on the specified research questions. One researcher, namely the author of this study, conducted the data extraction process. Several data points were obtained from the study. Related to participant characteristics, type of anxiety disorder based on the DSM-5 or ICD classification, age and gender were collected. Related to the study characteristics, the research design, its experimental condition, the sample size, number of assessment points, the type of VR technology used as well as the duration and the study aim were obtained. Furthermore, the perceived usability and feasibility of doing VRET, as rated by participants, is collected. Lastly, the used measurements regarding the effectiveness of the intervention were collected, as well as the results of these measurements.

Results

All in all, this scoping review investigated 20 studies concerned with treating anxiety disorders with VRET.

Participant Characteristics

The participant characteristics of the reviewed studies are displayed in Table 1. The average sample size is 50.2 (SD = 41,09) with a male/female ratio of 137/135. The mean age across all studies was 29.29 (SD = 9.2). Most studies were concerned with a specific phobia, such as fear of flying or spider phobia (n = 9) and PTSD (n = 6). The population which appeared in the most studies were soldiers with combat-related, treatment-resistant or military trauma-related PTSD (n = 6). Four studies had a target population of either children or youths and one study investigated students. Some studies looked at populations with comorbid disorders, such as specific phobia and autism (n = 2), social anxiety and PTSD (n = 1) and panic disorder with agoraphobia (n = 2). Most studies included both female and male participants (n = 17). Studies with combat-related or treatment-resistant PTSD mostly

included males (n = 5), while most other studies had more female than male participants (n = 10). One study had a participant of gender other.

Table 1

Participant Characteristics

Authors	DSM-5 diagnosis	Population	Gender	Age (years), mean (SD)
Beidel et al. (2019)	PTSD	Military veterans with combat-related PTSD	TMT group: male (n = 45), female (n = 4); EXP group: male (n = 41), female (n = 2)	TMT group: (M = 37.67, SD = 8.51); EXP group: (M = 33.26, SD = 11.31)
Gujjar et al. (2018)	Specific phobia	University dental clinic patients with dental phobia	VRET group: male (n = 7), female (n = 8) IP group: male (n = 5), female (n = 10)	VRET group: (M = 25.3, SD = 8.6) IP group: (M = 23, SD = 8.9)
Loucks et al. (2019)	PTSD	Veterans with military sexual trauma-related PTSD	Male (n = 4), female (n = 11)	32 to 72 years old (M = 46)
Maskey et al. (2019)	Specific phobia	Young people with autism spectrum disorder	Male (n = 8)	8 to 12 years old.
Maskey et al. (2019)	Specific phobia	Young people with autism spectrum disorder	TG: male (n = 13), female (n = 3); CG: male (n = 12), female (n = 4)	TG group: 7 to 14 years old (M = 13.13, SD = 28.38); CG group: 7 to 12 years old (M = 12.9, SD = 21.51)
Miloff et al. (2019)	Specific phobia	Patients with spider phobia	OS group: male (n = 8), female (n = 41, other (n = 1); VRET group: male (n = 16), female (n = 84)	OS group: (M = 34.04, SD = 9.85); VRET group: (M = 34.06, SD = 10.92)

Reger et al. (2019)	PTSD	Active duty U.S. Army soldiers with combat-related PTSD	PE group: male (n = 43), female (n = 4); VRET group: male (n = 46), female (n = 3)	PE group: (M = 30.74, SD = 6.97); VRET group: (M = 29.76, SD = 6.50)
Jiang et al. (2020)	Specific phobia	Patients with blood-injection injury phobia	VRET group: male (n = 3), female (n = 18); WLC group: male (n = 5), female (n = 17)	VRET group: (M = 22.38, SD = 4.74); WLC group: (M = 24.45, SD = 7.67)
Katz et al. (2020)	PTSD	Active duty soldiers with combat-related PTSD	PE group: male (n = 28), female (n = 1); VRET group: male (n = 26), female (n = 1); WL group: male (n = 28), female (n = 1)	PE group: (M = 31.26, SD = 6.63); VRET group: (M = 29.93, SD = 6.92); WL group: (M = 30.83, SD = 6.97)
Malbos et al. (2020)	Specific phobia	Patient with Squalophobia (fear of sharks)	Female, (n = 1)	30 years old
van Gelderen et al. (2020)	PTSD	Veterans with treatment-resistant PTSD	CG: male (n = 21); 3MDR group: male (n = 21), female (n = 1)	CG: (M = 41.93, SD = 9.12); 3MDR group: (M = 42.41, SD = 9.80)
Whiteside et al. (2020)	Generalised anxiety disorder	Youths with generalised anxiety disorder	Male (n = 6), female (n = 14)	8 - 18 years old (M = 13.80, SD = 2.88)
Farrell et al. (2021)	Specific phobia	Children with dog phobia	Male (n = 4), female (n = 4)	8 - 12 years old (M = 10.25, SD = 2.11)
Jeong et al. (2021)	Social phobia	Patients with social phobia	ET group: male (n = 28), female (n = 24); NT group: male (n = 32), female (n = 11); SE group: male (n = 15), female (n = 5)	ET group: (M = 34.3, SD = 13.3); NT group: (M = 31.2, SD = 15.5); SE group: (M = 27.6, SD = 10.7)
Leehr et al.	Specific	Patients with spider	SM: male (n = 15), female (n = 70);	SM: (M = 27.33, SD = 8.35);

(2021)	phobia	phobia	SW: male (n = 12), female (n = 75)	SW: (M = 29.39, SD = 9.63)
Shin et al. (2021)	Panic disorder	Patients with panic disorder	VRET group: male (n = 13), female (n = 21); WG: male (n = 7), female (n = 14)	VRET group: (M = 35.84, SD = 10.37); WG: (M = 37.14, SD = 13.54)
Trahan et al. (2021)	Social phobia and PTSD	Student veteran with social anxiety and PTSD	Male (n =1)	36 years old
(Zainal et al., 2021)	Social phobia	Community-dwelling or undergraduate adults with social anxiety	Male (n = 12), female (n = 32)	(M = 23.30, SD = 9.32)
(Lundin et al., 2022)	Panic disorder with agoraphobia	Patients with panic disorder with agoraphobia	Male (n = 3), female (n = 9)	(M = 40.8, SD = 15%)
(Meyerbröker et al., 2022)	Specific phobia	Patients with fear of flying	Male (n = 20), female (n = 47)	(M = 36.71, SD = 11.74)

Note: Explanation of acronyms used in the table: CG = control group; ET = earl termination; EXP = exposure therapy; IP = information pamphlet; NT = normal termination; OS = one-session; PE = Prolonged exposure**;** SE = session extension; SM = Sample Muenster; SW = Sample Wuerzburg; TG = treatment group; TMT = trauma management therapy; WG = waitlist group; WLC = wait list control

Study Characteristics

The study characteristics are displayed in Table 2. Most of the studies were randomised controlled trials (RCT) (n = 10). Additionally, there were several studies using a single case experimental design (n = 6) and feasibility studies (n = 3). One study was an open trial, using retrospective data which was collected in a previous study (Jeong et al., 2021). Due to the inclusion rules, all studies contained VRET. Some studies used VRET alongside CBT (n = 3) and one study used a special type of VRET called 3MDR. In most studies participants completed several VRET sessions (n = 14), while the rest included only one session of VRET (n = 6). The studies with multiple VRET sessions ranged from 4 to up to 29 VRET sessions. The VRET session length differed from 10 minutes up to 3 hours. In most studies, VRET was administered by a professional (n = 19), whereas in one study, VRET was self-guided.

Based on the inclusion criteria, all studies were concerned with the effectiveness of treating anxiety disorders with VRET. Yet, some studies did not have this as their sole focus. In one study, the benefits of adding trauma management therapy to VRET was investigated. In other studies, the feasibility and/or acceptability of VRET was focused on (n = 3). Another study focused on exploring predictors for making VRET successful by employing a machine learning algorithm (n = 1), and yet another study focused on the amount of emotional engagement in VRET (n = 1).

With regards to the type of VR technology used, most studies used VR administered by a head-mounted display (n = 18). The other two studies used “flat screen computer-delivered VR” or a setup in which “audio visual images [are] projected onto the walls and ceilings of a 360 degree screened room”. Some studies explicitly stated that they used an additional headset to provide sound (n = 3). Furthermore, some studies used joysticks or other handheld devices with which participants can navigate the VR-environment (n = 4).

Some studies manipulated the odour of the environment to match the VR-content (n = 3). Additionally, some studies incorporated platforms which are able to simulate vibrations (n = 4). Notably, one study treating Dental Phobia seated patients in a dental chair to increase immersion, while another propped joysticks on a mock-riffle to simulate warfare.

Table 2

Study Characteristics

Authors, mental disorder	Research Design	Intervention			
		Experimental conditions, sample size	Duration	Study aim	Type of VR technology
Beidel et al. (2019), combat-related PTSD	RCT	TMT vs. EXP , n = 92	VRET 3 times a week for 5 weeks. Then treatment based on the group for the rest of the study. In total 29 treatment sessions over 17 weeks.	Comparing the efficacy of TMT, consisting of VRET plus group treatments for anger, depression and social isolation, with the efficacy of VRET plus psychoeducational control condition.	Virtual Afghanistan/Iraq System, including Wizard of Oz interface, using head-mounted display, earphone, scent machine and rumble platform
Gujjar et al. (2019), dental phobia	RCT	VRET vs. IP, n = 30	VRET group: baseline phase (10 minutes), training phase (2 minutes), experimental phase (duration of completing 5 VR-scenarios) IP group: up to 45-minutes	Study to investigate the effects of VRET to treat dental phobia by lowering dental anxiety and behavioural avoidance	VR dental scenarios; participants seated in dental chair, surrounded by soaked cotton wool to elicit “operatory related odour”
Loucks et al. (2019), MST-related	Feasibility study	VRET, n = 15	6-12 VRET sessions	Investigating VRET to treat MST-related PTSD, by using novel content tailored towards	BRAVEMIND virtual reality system with MST-specific content;

PTSD				MST.	sound and lightning controllable by therapist
Maskey et al. (2019), specific phobia	Single case experiment al design	Psychoeducation + VRET with CBT, n = 8	One psychoeducation session, four 20 minute VRET sessions	Trial investigating VRET for young people with a specific phobia and autism.	"[F]lat screen, computer–delivered virtual reality", where "[t]he psychologist operated the graded computer generated scene via an iPad"
Maskey et al. (2019), specific phobia	RCT	VRET alongside CBT vs. CG, n = 32	"[O]ne session introducing CBT techniques and four VRET sessions"	RCT to test effectiveness of VRET to treat specific phobias in young people with autism.	Blue Room VRET, "using interactive computer generated audio visual images projected onto the walls and ceilings of a 360 degree screened room"
Miloff et al. (2019), spider phobia	RCT	VRET vs. OS, n = 100	One-session-treatment with VRET (about 3h long)	Study to compare single-session VRET for treating spider phobia to in-vivo one-session treatment	Samsung Gear VR system, including touchpad + "inexpensive over the ear headphones"
Reger et al. (2019), combat-related PTSD	RCT	PE vs. VRET, n = 108	Ten sessions. 2 psychoeducation, 7 sessions in vivo exposure or VRET, depending on condition.	Study comparing prolonged exposure and VRET with regards to treating PTSD symptoms and eliciting emotional engagement.	Virtual Iraq/Afghanistan system, using head-mounted display, gaming joystick attached to mock rifle, headphones, scent palette, platform able to imitate vibrations
Jiang et al. et al. (2020),	RCT	VRET vs. WLC, n = 43	One session VRE	Study examining the acceptability and efficacy of a single-session	Samsung Gear VR headset, includes integrated

blood-injection injury phobia				VRET intervention to treat BII phobias.	touchpad, sound and motion tracking.
Katz et al. (2020), combat-related PTSD	RCT	PE vs. VRET vs. WLC, n = 90	"The two active treatments (PE and VRET) involved 10 weekly or twice weekly" (depending on participant's schedule)	Comparing the impact of VRET and PE on psychophysiological variables in soldiers with combat-related PTSD.	Head-mounted VR display; sight, sounds and events can be manipulated, platform to imitate vibrations
Malbos et al. (2020), squalophobia	Single case experiment al design	VRET, n = 1	Weekly sessions: 4 CBT, followed by 6 VRET sessions	Case study for treating squalophobia with VRE	VR head-mounted display, wireless controller with directional pad, headphones
Van Gelderen et al. (2020), treatment-resista nt PTSD	RCT	CG vs. 3MDR ("novel virtual reality and motion-assisted exposure therapy"), n = 43	3MDR group: 6 standardised weekly 3MDR sessions, followed by 10 optional weekly sessions; CG: non-specific treatment, administered up to 16 weeks, depending on necessity	Trial investigating the effectiveness of 3MDR for treating veterans with treatment-resistant PTSD.	3MDR, administered on dual-belt treadmill with synchronised VR environment containing 180-degree projection on 3 screens and surround sound system
Whiteside et al. (2020), childhood anxiety disorder	Feasibility study	Verbal IE + VRET, n = 20	One session, IE and VRET applied in randomised order	Study testing the feasibility of verbal and VR exposure in youth with academic performance worry	Google Pixel Android smartphone + strap-on headset + handheld motion controller

Farrell et al. (2021), specific phobia of dogs	Single case experimental design	VRET, n = 8	VRET one-session treatment	Study investigating the efficacy of VR one-session-treatment for children with a special phobia of dogs	Oculus Rift VR-headset
Jeong et al. (2021), social anxiety disorder	Open trial	ET group (< 9 sessions) vs. NT group (9 - 10 sessions) vs. SE group (> 10 sessions), n = 115	9 - 10 weekly VR-based CBT sessions; if needed extended to more than 11 sessions	Study investigating if VR-based individual CBT improves social anxiety disorder.	VR system, containing monitoring system of eye movements, speaking time and heart rate
Leehr et al. (2021), spider phobia	Single case experimental design	VRET (conducted at two different sites), n = 174	Psychoeducational material for at home, one VRET session	Study trying to identify variables which predict VRET treatment response for spider phobia.	Head-mounted display
Shin et al. (2021), panic disorder	RCT	VRET vs. WG, n = 54	VRE: 3 sessions over 4 weeks, 12 sessions total	Study investigating the effectiveness of an app-based, self-led VR CBT to treat panic disorder.	Gear VR (Samsung Electronics)
Trahan et al. (2021), social anxiety and PTSD	Single case experimental design	VRET, n = 1	12 sessions of VRE	Study investigating the effectiveness of mobile phone based VRET to treat PTSD and social anxiety	Mobile VR intervention, using a VR headset
Zainal et al. (2021), social anxiety	RCT	VRET vs. WL, n = 44	VRE: four or more self-guided sessions	Study examining the effectiveness of a self-directed VRET intervention to treat SAD.	VR headset, able to detect and identify head position and movement
Lundin et al.	Feasibility	VR-CBT, n = 12	10-12 week VR-CBT	Study investigating the	VR-headset

(2022), panic disorder with agoraphobia	study		programme	acceptability and feasibility of treating PDA with VR-CBT based on environments created with a low-cost 360-degree film camera.	
Meyerbröker et al. (2022), fear of flying	Single case experimental design	VRET, n = 67	Four weekly VRET sessions	Study to investigate effectiveness of treating fear of flying with VRE	VR-headset, chair with subwoofers to simulate vibrations

Note: Explanation of acronyms used in the table: CG = control group; ET = earl termination; EXP = exposure therapy; IE = imaginary-exposure; IP = information pamphlet; NT = normal termination; OS = one-session; PE = Prolonged exposure**;** RCT = Randomised controlled trial; SE = session extension; SM = Sample Muenster; SW = Sample Wuerzburg; TG = treatment group; TMT = trauma management therapy; WG = waitlist group; WLC = wait list control

Usability Feasibility, and Effectiveness

Table 3 contains information regarding the usability, feasibility and effectiveness of the investigated studies. Regarding drop-outs, studies differed considerably. Some studies reported no or low drop-out rates (n = 8), others reported medium-level drop-outs similar to other studies (n = 3) and yet other high-levels of drop-outs (n = 3). Furthermore, studies reported only little to medium levels of cybersickness (n = 4) and high acceptance of VR (n = 5). Some studies reported neither drop-out rates nor how patients perceived the usability of VR (n = 4).

In the studies, a wide range of measurement tools were used to assess the effectiveness of the intervention, most of them were scales. These scales were commonly used to assess symptoms of a specific anxiety disorder, such as the PCL-5 (n = 4) and CAPS (n = 4) to assess PTSD symptoms. Many studies assessed anxiety (n = 15) and depression symptoms (n = 8) by using scales such as the SUDS for anxiety (n = 3) or the PHQ-9 for depression (n = 2). Some studies assessed physiological data, such as heart rate response (n = 3) or galvanic skin response (n = 1). Some studies used qualitative data, such as participant feedback or interviews (n = 2). All studies assessed the effectiveness measures pre- and post-treatment. Most studies also included one (n = 7) or several follow-up measurements (n = 7), which were assessed between one up to twelve months after post-treatment.

Regarding the measured effectiveness of treating anxiety disorders with VRET, most studies reported an improvement in anxiety disorder symptoms after VRET (n = 18). Likewise, many studies reported a significant improvement in other relevant measures, such a decrease in anxiety (n = 5), or depression symptoms (n = 4). However, in some studies these improvements did not differ from the control group. For example, in one study prolonged exposure was as effective as VRET in treating PTSD, and in another study imaginary exposure elicited similar levels of anxiety as VRET, indicating that VRET did not have an

advantage for exposure therapy compared to conventional methods. Likewise, another study found that exposure therapy had better short-term results with regards to spider-phobia compared to in-vivo exposure, but both methods had the same impact at follow-up. Most studies with follow-up measurements reported that the positive changes due to VRET were maintained at these measurement points (n = 12). One study investigated the effect of the number of VRET sessions and found that the amount of sessions did not have an impact for social anxiety related measures.

Table 3

Usability and Feasibility, and Effectiveness

Authors, mental disorder	Perceived usability and feasibility	Measure to assess effectiveness	Assessment points	Measured effectiveness
Beidel et al. (2019), Combat-related PTSD	39% dropout rate, "consistent with other clinical trials examining treatment for combat-related PTSD"	PTSD symptoms (PTSD scale, PCL-5), depression (HAMD), anxiety (HAMA), anger, sleep and social isolation (self-monitoring)	Mid- and post-treatment, 3- and 6 months follow-up	For both groups, significant decreases in PTSD symptoms, and in anger and depression. Significant decreases in social isolation for the TMT group only. All treatment gains were maintained six-months later. Sleep did not improve.
Gujjar et al. (2019), Dental phobia	Mild cybersickness in some patients. Less than in the feasibility study (Gujjar et al., 2018), probably due to more breaks	State anxiety (VAS-A), dental trait anxiety (MDAS and DFS), behavioural avoidance (BAT), heart rate response, VR experience, dental attendance	Baseline, pre- and post-intervention, 1-week, 3-months and 6-months follow-up	For the VRET group compared to the IP group, significant reduction in anxiety scores, behavioural avoidance. At 6-month follow-up less patients which fulfil dental phobia criteria in VRET group.
Loucks et al. (2019), MST-related PTSD	"Results indicated dropout rates consistent with other PE treatment studies with military samples, and there were no reports of adverse effects or critical incidents in response to VRET implementation."	PTSD (CAPS, PCL-5), heart rate	Pre-treatment, post-treatment, 3-month follow-up	Significant reduction in PTSD and depressive symptoms which was maintained at follow-up. Also, significant reduction in heart rate response to a trauma cue.

Maskey et al. (2019), Specific Phobia	Only one dropout at follow-up, for family related reasons.	Anxiety symptoms (SCAS-P, SCAS-C), target behaviours, confidence ratings (regarding tackling the behavioural goal)	Baseline, 6 weeks, 6 months and 12 months after intervention	"Four of the participants were classed as responders to the intervention and were able to function without the fear/phobia impacting their life. These improvements were maintained 12 months post-intervention."
Maskey et al. (2019), Specific Phobia	No dropout in VRET treatment sessions. "For the immediate treatment group, most child and parent confidence ratings for tackling the goal situation increased [from the first to the last session]"	Target behaviour ratings, anxiety symptoms (SCAS-P, SCAS-C), fearfulness (FSSC-R), participation enjoyment (CAPE)	Baseline, 2 weeks, 6 months and 12 months (immediate treatment group only) months after treatment	"Two weeks after treatment, four treatment participants (25%) and no control participants were responders; at 6 months after treatment, six (38%) treatment and no control participants were responders. At 6 months post-treatment, symptoms had worsened for one treatment and five control (untreated) participants."
Miloff et al. (2019), Spider phobia	Relatively low dropout rates (2 participants prior treatment, 1 prior post-assessment & 3 at post-treatment).	Behavioural approach test (BAT) and self-rated fear of spider, anxiety, depression and quality-of life (GAD-7, PHQ-9, BBQ, NEQ-32, IPQ)	Pre- and post-treatment, follow-up (3 and 12 months)	"VRET efficaciously reduced spider phobia symptoms in the short-term and was non-inferior to in-vivo exposure therapy in the long-term."
Reger et al. (2019), combat-related PTSD	High dropout rates (44% for VRET group, 41% for PE group)	Discomfort/distress (SUDS), PTSD symptoms (CAPS), trauma similarity to VR (rated by two psychologists)	SUDS for every session, for other scales baseline + post-treatment	Decrease in distress and PTSD symptoms across sessions in both groups. No difference between groups, indicating that VRET "may not have increased emotional engagement over and

				above PE”
Jiang et al. et al. (2020), Blood-injection injury phobia	Modest attrition, similar to related literature	Medical fears (MFS), blood phobia (MBPI), dental anxiety (MDAS), credibility and expectancy (CEQ), cognitive assessment (administered by clinicians)	Baseline, one-week post treatment and 3-month follow-up	The VRET group had significantly greater reductions in self-reported fears of injections, injury, and fainting compared to the WLC group. No significant group differences in fears of sharp objects, medical examinations and hospitals, fear of mutilation, dentists or blood
Katz et al. (2020), combat-related PTSD	Relatively high drop-out rate (only 60% completing all 10 VRET or PE sessions)	Physiological reactivity (GSR), PTSD symptoms (CAPS), anxiety (BAI), depression (BDI)	Pre-, mid-, post-treatment	“[...] Only the VRET group differed significantly from WL [in GSR reactivity to trauma]. Across the sample, reductions in GSR were significantly correlated with reductions in self-reported PTSD and anxiety symptoms.”
Malbos et al. (2020), squalophobia	Little cybersickness	Depression (BDI), anxiety (STAI), general health (SF-12), squalophobia-related cues (SRCQ), discomfort (SUD)	Pre- and post-treatment, 12-month follow-up; SUD every 5 min during VRET,	Reduction in fear towards sharks, maintained at 12-month follow-up; presence rated indicated immersion
Van Gelderen et al. (2020), treatment-resistant	“The dropout rate was low (7%)” which might be “indicative of high engagement”	PTSD symptoms (CAPS-5, PCL-5), depression and anxiety symptoms (HADS), daily life avoidance (PABQ), quality of life (Cantril’s	Baseline, after 3MDR, 12-week and 16-week	“The decrease in PTSD symptom severity from baseline to endpoint was significantly greater for 3MDR as compared to the control

		Ladder of Life), and perceived social support (Support Evaluation List)	follow-up	group, with a large effect size"; 45% of the patients in the 3MDR group improved clinically.".
Whiteside et al. (2020), childhood anxiety disorder	Both IE and VRET both found to be acceptable with no observed side-effects. VRET deemed as more interesting and novel, IE as more realistic and individualised	Anxiety (SUDS), physical side effects (SQQ), preference ratings (interview)	At beginning and throughout each exposure and exposure ended	"[B]oth verbal IE and VRET elicited moderate anxiety that decreased to mild over the span of the exposures."
Farrell et al. (2021), specific phobia of dogs	Not specified	Anxiety disorders (ADIS-P), target symptoms (parent's rating), behavioral approach test, anxiety symptoms (SCAS-C/P), fear (FSSC-R-C), perceived reality of VR stimuli (likert scale)	Baseline (2, 3 or 4 weeks), pre- and post-treatment, 1 month follow-up	Phobia symptoms stable over baseline, significant reduction from pre- to post-treatment and to follow-up; 75% of children considered as "recovered at 1-month follow-up; "no correlations between level of reality and treatment outcomes"
Jeong et al. (2021), social anxiety disorder	Not specified	Fear of negative evaluation (BFNE), social anxiety & avoidance in social situations (LSAS), fears of being scrutinised during routine activities (SPS), complementary aspects of social phobia (SIAS)	Pre- and post-treatment	For all groups, fear of negative evaluation decreased as sessions progressed, no significant group differences for social anxiety and avoidance in social situations.
Leehr et al. (2021), spider phobia	Not specified	Clinical and sociodemographic predictors, spider phobia symptoms (SPQ), behavioural avoidance (BAT)	Pre- and post-treatment, 6-month follow-up	Significant reduction in SP symptoms and behavioural avoidance at follow-up; regarding the machine learning model:

				"[i]ndividual short-term symptom reductions could be predicted above chance, but accuracies dropped to non-significance in our between-site prediction and for predictions of long term outcomes."
Shin et al. (2021), panic disorder	"[M]any participants completed the whole treatment process although they had never used VR devices, indicating the decent usability of VR." and the study indicates "that mobile-based VR can be used by patients alone and exhibit positive results."	Panic disorder symptoms (PDSS), depression (HRSD), body sensations (BSQ), fear in various situations (APPQ), trait anxiety (STAI), depression and anxiety (HADS), social avoidance and distress (K-SADS), depression symptoms (KIDS-SR), perceived stress (PSS), simulator sickness (SQQ), heart rate (SA-3000P aertial testing device)	Pre- and post-treatment, 4-weeks follow-up	VR group improvements in panic disorder symptoms, anxiety and depression after four weeks; no significant improvements for WG; VR group significant improvements over WG with regards to panic disorder severity and intention-to-treat
Trahan et al. (2021), social anxiety and PTSD	Not specified	Sleep quality (PSQI), motion sickness (MSQ), PTSD symptoms (PCL-5, SCl-90), to control these variables in a larger study (Five Face Mindfulness Scale, Tellegen Absorption Scale)	Pre- and post-treatment	Significant improvement in social anxiety, PTSD and sleep quality; subjective improvement in stress levels; improved neurological connectivity
Zainal et al. (2021), social anxiety	"[P]articipants' feedback largely suggested that the VRET was acceptable, presence and cybersickness levels were better or comparable to other VRET,	Social phobia symptoms (SPDQ, SIAS), job interview anxiety (MASI), trait worry (PSWQ), depression symptoms (PHQ-9), qualitative feedback	Baseline, post-treatment, 3 and 6-month follow-up	VR (compared to WL) "resulted in greater reductions in SAD symptom severity, job interview fear, and trait worry, with moderate-to-large effect sizes"; reduced depression in VRET

	most participants were compliant with homework, and a majority reached their most difficult scenes, demonstrating feasibility of the self-help protocol."			group but no significant group differences; changes stable in follow-up; decrease in cybersickness
Lundin et al. (2022), panic disorder with agoraphobia	High treatment satisfaction, no drop-outs	Agoraphobia symptoms (MIA), panic disorder symptoms (PDSS-SR), depression (PHQ9), functional impairment (WHODAS), quality of life (WHOQOL), acceptability (CSQ-8)	Pre- and post-treatment, 6-month follow-up	Significant improvement in PDA at post-treatment and follow-up, with large effect-sizes
Meyerbröker et al. (2022), fear of flying	22 (of total 67) participants dropped out during study	Flight anxiety (FAS), self-efficacy (SEQ), working alliance (WAI), anxiety (ASI), discomfort (SUD)	Pre- and post-treatment and the individual sessions	"[P]re-treatment levels of anxiety sensitivity, initial improvement in self-efficacy (and not pretreatment levels of self-efficacy), and the quality of the therapeutic alliance significantly predicted treatment outcome."

Note: Explanation of acronyms used in the table: CG = control group; ET = earl termination; EXP = exposure therapy; IE = imaginary-exposure; IP = information pamphlet; NT = normal termination; OS = one-session; PE = Prolonged exposure**;** SE = session extension; SM = Sample Muenster; SW = Sample Wuerzburg; TG = treatment group; TMT = trauma management therapy; WG = waitlist group; WLC = wait list control

Discussion

This scoping review aimed to review research conducted since 2019 on the effectiveness of treating anxiety disorders with VRET in clinical populations. In total, 20 studies were reviewed. From these, information was extracted regarding the participant and study characteristics, as well as information regarding the usability, feasibility, and effectiveness of the VRET treatment.

The anxiety disorder which was the most common in the reviewed literature were specific phobias. Some of these were related to more common specific phobias, such as social anxiety or fear of spiders, while others were more unorthodox, such as fear of sharks. Most investigated studies focused on populations suffering from one single type of anxiety. Yet, anxiety disorders are often comorbid with other anxiety and mental health disorders (Kessler et al., 2009) which influences the treatment approach, as it is usually recommended to prioritise treating the most impairing disorder first (Sherbourne et al., 1996). Thus, one should be careful to generalise the findings of the reviewed studies to populations with comorbid anxiety disorders, because treatment course and outcomes might differ.

The population which was investigated in most studies were soldiers with either combat or military sexual trauma-related PTSD and notably, there were no studies which investigated other populations suffering from PTSD. Previous literature studies on VRET and PTSD already noted this imbalance and its entailing problems (Deng et al., 2019; Kothgassner et al., 2019) which seem to persist in the current literature. PTSD has a wide spectrum of affected populations (Deng et al., 2019), yet most available research is based on a very specific population, namely veterans with military related PTSD. This discrepancy limits the generalizability and future research is strongly warranted to investigate the effectiveness of VRET for these other populations as well.

Regarding gender, most studies included both female and male participants and the male/female ratio across all studies is almost equal (137:135). Yet, looking at the individual studies reveals that the gender distribution between studies is often heavily skewed to either direction. For example, studies with combat-related PTSD mostly included male participants (Beidel et al., 2019; Katz et al., 2020; Reger, Smolenski, Edwards-Stewart, et al., 2019), and so did studies concerning participants with autism and a specific phobia (Maskey, McConachie, et al., 2019; Maskey, Rodgers, et al., 2019). On the other hand, studies investigating specific phobias of spiders included considerably more women than men (Leehr et al., 2021; Miloff et al., 2019). It seems that gender distributions in the present studies are moderated by anxiety disorder type and therefore, one should be cautious when averaging gender ratios across studies which investigate different anxiety disorders, and careful in generalising findings of these studies to all genders.

In addition, the gender distribution can be skewed even within one type of anxiety disorder. For example, in total, there are more men suffering from combat-related PTSD (Vogt et al., 2011) which is reflected in the samples of reviewed research (Beidel et al., 2019; Katz et al., 2020; Reger, Smolenski, Edwards-Stewart, et al., 2019). On the other hand, PTSD related to sexual abuse is more frequent in women (Kimerling et al., 2018) which is reflected in the samples of reviewed research as well (Loucks et al., 2019). Notably, previous literature reviews regarding VRET and PTSD did not collect gender-related data (Deng et al., 2019) and therefore lacked this finding. Lastly, only one participant identified as diverse across all studies. This mirrors the research gap related to non-binary people, as these are more likely to suffer from anxiety disorders than people who identify as either male or female, but are underrepresented in empirical studies (Thorne et al., 2019).

Most of the reviewed studies were RCTs. These studies usually investigated common anxiety disorders, such as PTSD or panic disorders, and used validated VRET methods, such

as administering several VRET sessions. As RCT is the gold standard for effectiveness research, this finding indicates that much of the research on VRET and anxiety disorders is done on a high methodological level and that their findings have a high informative value which is in line with previous literature studies (Deng et al., 2019; Wechsler et al., 2019). On the other hand, there were also several studies using a single case case experimental design and the reasons for this might vary. For some studies focusing on a rare form of a specific phobia, such as fear of sharks, recruiting participants might be difficult and funding for these studies might not be that readily available since the societal burden is relatively low (Malbos, Burgess, et al., 2020), and thus sample sizes are low. In other cases, studies using a single case experimental design were exploring novel approaches, and aimed to lay the groundwork and justification for more elaborate, large-scale studies. Examples of such novel approaches are self-administered VRET or VRET administered with a flat-screen, which showed promising results in the conducted studies (Maskey, McConachie, et al., 2019; Trahan et al., 2021).

In most studies, VRET was administered in several sessions. In the other ones, the single session-setup was usually part of the research question, thus not due to financial or time-related concerns. There is also a huge variety of session lengths, ranging between 4 and 29 sessions. One study explicitly compared the impact session number on treatment outcome and found no differences between participants receiving 9-10 sessions and participants receiving more sessions, and even suggested that 5-6 sessions can be effective (Jeong et al., 2021). Contrasting to this, previous literature reviews found a close-response relationship between VRET sessions and treatment outcome, indicating that 8 to 10 sessions are more effective than less sessions. However, these reviews did not include many or any studies with more than 10 sessions (Deng et al., 2019; Powers & Emmelkamp, 2008), and thus they do not

offer any insights on whether this dose-response effect dips after 10 sessions, as indicated in the research by Jeong et al. (2021).

There were also substantial differences in the type of VR technology used. Most studies used a VR-headset, often accompanied with headphones. Some studies, however, improved the degree of immersion drastically by adding chairs, vibration eliciting platforms, or odour cues. Furthermore, several studies utilised joysticks through which participants could navigate through the VR-environment, with some joysticks matching the environmental settings, such as joysticks mounted on a mock-riffle in a simulated war scenario. Research indicates that a higher degree of immersion is beneficial for VRET outcomes (Maples-Keller et al., 2017), and therefore these more elaborate setups are advisable when conducting VRET interventions.

The characteristics of the used VR environments differed as well. Studies focusing on widely researched anxiety disorders could use pre-existing and sophisticated VR-environments with a high degree of immersion, such as the BRAVEMIND system developed for treating combat-related PTSD (Loucks et al., 2019), while studies focusing on less common or well researched anxiety disorders, such as specific phobia of sharks, had to create their own VR-environment (Malbos, Burgess, et al., 2020). These differences mirror the real world obstacles patients face when seeking VRET, namely a lack of institutions offering VRET and a lack of VR-environments applicable for patients (Malbos, Burgess, et al., 2020). This is especially unfavourable for patients suffering from an anxiety disorder which is difficult to treat with conventional exposure therapy.

Novel technological approaches were also present, such as delivering VRET via a mobile-device (Trahan et al., 2021). However, there is still potential to utilise novel VR-features, such as eye-tracking (Eira, 2023). For example, one study combined VRET with eye movement desensitisation and reprocessing therapy (EMDR) (van Gelderen et al., 2020),

and future studies combining VRET with EMDR might benefit from adding eye-tracking to their study design. On the other hand, while using a commonVR-setup, another study still employed novel technological approaches by utilising machine learning to identify predictors for treatment response (Leehr et al., 2021). This showcases that, unrelated to advances in VR-technology itself, VRET research also benefits from advances in other technological domains, such as using artificial intelligence to improve analytical capabilities and to allow for new research designs.

Drop-out rates differed across the reviewed studies, and drop-out levels between high and low were reported. Moreover, several studies reported high VR acceptance and little cybersickness, which indicates that VR has a high applicability. Several studies did not report any drop-out rates or feasibility related insights, which is something to be improved upon, as these insights are essential for evaluating new interventions. Assessments of anxiety symptoms and other relevant measures were usually conducted by using established questionnaires, such as the CAPS to assess PTSD-symptoms. Moreover, most studies included one or more follow-up assessments, with a range from one up to three follow-up assessments. This would be advisable for all studies, as reliable follow-up data is crucial for assessing the outcomes of clinical trials (Clark et al., 2002; Editors, 2013).

A few studies investigated factors which might influence the effectiveness of VRET. For example, one study investigated whether the amount of sessions made an impact on social anxiety symptoms, and found no difference between 8 or more sessions (Jeong et al., 2021). Another study investigated the emotional engagement during exposure therapy, and found no differences between VRET and prolonged exposure (Reger, Smolenski, Norr, et al., 2019).

Regarding the effectiveness of VRET to treat anxiety disorders, most VRET interventions lead to an improvement in anxiety disorders, and improvement on related

symptoms, such as depression, was also frequently found. These improvements were mostly maintained at follow-up assessments which indicates that VRET is an impactful intervention whose benefits are maintained over time. Nevertheless, in some studies the control-groups showed the same improvements as the VRE-groups. It should be noted, however, that in those studies control groups often consisted of established exposure interventions, such as imaginary exposure, and not merely of waitlist groups or psychoeducation. These findings regarding the effectiveness of VRET were in line with previous literature searches. For example, it was found that VRET is comparable to in vivo exposure for specific phobias and agoraphobia (Wechsler et al., 2019) and is impactful in treating PTSD (Deng et al., 2019). Regarding social phobia, previous research showed no clear indication that VRET is equivalent to in vivo exposure and therefore recommended it as an addition to traditional CBT, rather than as stand-alone intervention (Wechsler et al., 2019). This review investigated three studies related to social phobia, all of which found reduced social phobia symptoms in patients after VRET (Jeong et al., 2021; Trahan et al., 2021; Zainal et al., 2021), indicating that VRET can be a valuable stand-alone intervention. However, these studies did not compare VRET with in-vivo exposure, thus it cannot be concluded whether VRET is preferable over in-vivo exposure therapy to treat social phobias.

Study Limitations

The present study was conducted by a single researcher, thus the study selection procedure was done by only one rater which potentially threatens this study's reliability. Furthermore, this study incorporated strict inclusion criteria, such as participants needing a DSM-5 diagnosis of an anxiety disorder, and only including peer-reviewed articles. This process might have excluded interesting studies. For example, studies with non-clinical populations might contain findings which are relevant for clinical populations as well, and non peer-reviewed articles might still provide valuable information about where the field is

heading to. To circumvent this issue, future research might aim to broaden the inclusion criteria.

Furthermore, this study did not report effect-sizes which makes it harder to assess the importance of the reviewed studies and how the different study designs, such as number of VRET sessions, impacted treatment outcome (Durlak, 2009). Lastly, the present study is a scoping review, and thus it aims to provide a general overview over the current research status of the investigated field. It does not, however, aim to assess the quality of the screened studies or synthesise effectiveness of interventions in the form of meta-analyses.

Directions for Future Research

During the study selection process it was noted that many of the screened studies lacked research information, such as specifying how participants were diagnosed (Donker et al., 2020; van ’t Wout-Frank et al., 2019). As such information is crucial for conducting sound literature research, it is advised that future studies include all relevant information in their study design. Furthermore, the study selection process revealed that established questionnaires to assess some specific phobias are lacking (Cherestal et al., 2021). Thus, future research should aim to establish sound measurement tools for assessing these types of anxiety disorders.

On another note, previous literature research has noted the need for detailed mediation analyses for this domain (Deng et al., 2019), and thus, it would be worthwhile to investigate possible moderators and mediators influencing VRET effectiveness. For example, research indicates that VR-immersion impacts how effective the intervention is (Weibel et al., 2010), and future research could investigate to which degree VR-graphics influence VRET effectiveness. Similarly, future research could investigate which participant characteristics, such as age or gender, moderate VRET treatment outcomes. Previous literature studies already noted obstacles related to this, such as being able to recruit large enough groups

(Kothgassner et al., 2019). Similarly, most of the investigated studies did not report the nationality and/or ethnicity of participants. As studies indicate that race can be a moderator with regards to anxiety disorders (Gómez, 2021), future studies should collect and report these variables as well. Additionally, future research should aim to balance relevant participant characteristics, to improve the validity when making inferences from a study to the general population.

It is also important to note that the adoption of a novel e-health technology by professionals and their implementation on a structural level, such as VRET, does not solely depend on its effectiveness and applicability. For example, lack of knowledge about novel technological tools or lack of training about their usage, might hinder the adoption process, even if research indicates great benefits for using those new tools (Feijt et al., 2018; Maheu, 2017). This is also relevant for VRET, since its effectiveness for treating anxiety disorders has been pointed out by research for quite a long time already (Feijt et al., 2018; Maples-Keller et al., 2017; Powers & Emmelkamp, 2008), yet other factors might hinder a widespread adoption by professionals and its clinical implementation. For this reason, future research could examine which factors hinder or facilitate the adoption and implementation process of VRET to treat anxiety disorders.

Conclusion

This scoping review found good indications that VRET is effective in treating anxiety disorders, and often performs as good or better than in vivo exposure therapy. Interesting and novel approaches, such as self-administered VRET show promising results, and the utility of VR seems to improve with time, as immersion increases and technical related issues, such as cyber sickness, seem to be relatively rare. However, there are imbalances when it comes to the amount of research dedicated to certain anxiety disorders and populations which strongly limits generalizability. Furthermore, the moderating and mediating factors which lead to

effective VRET-treatment are hard to assess based on the current research. Future research should try to mitigate these issues by focusing on less researched populations and anxiety disorders, and try to identify the factors which influence the effectiveness of VRET.

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