Treatment of Storm Fears Using Virtual Reality and Progressive Muscle Relaxation [1]

EXPANDED VERSION

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Background: The present study examined the efficacy of virtual reality (VR) exposure therapy for treating individuals with storm fears by comparing a one-session VR exposure treatment to a one-session progressive muscle relaxation (PMR) and psychoeducation session. **Aims:** It was predicted that there would be a reduction in storm-related fear posttreatment for individuals in both conditions, but that this reduction would be greater for those in the VR exposure condition. It was predicted that improvements would be maintained at 30-day follow-up only for those in the VR exposure condition. **Method:** Thirty-six participants each received one of the two treatment conditions. Those in the PMR treatment group received approximately 30 minutes of PMR and approximately 15 minutes of psychoeducation regarding storms. Those in the VR treatment group received approximately 1 hour of VR exposure. Additionally, participants were asked to complete a pretreatment and posttreatment 5-minute behavioural approach test to assess changes in storm fears. They were also asked to complete a measure assessing storm phobia. **Results:** There was a significant interaction between treatment group and self-reported fear at posttreatment, such that fear decreased for both groups, though the reduction was stronger in the VR group. Results also showed that reductions in storm fear were maintained at 30-day follow-up for both groups. **Conclusions:** Although this study used a small nonclinical sample, these results offer preliminary support for the use of VR exposure therapy in the treatment of storm-related fear.

Key words: specific phobia, storm phobia, virtual reality, exposure therapy, progressive muscle relaxation

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Introduction

Anxiety disorders are one of the most widespread classes of psychological disorders (Kessler, Berglund, Demler, Jin, & Walters, 2005). One of the most common anxiety disorders is specific phobia, with a lifetime prevalence rate of 12.5% (Kessler et al., 2005). Specific phobia is characterized by a disproportionate fear or anxiety in the presence of a specific object or situation, and is typically accompanied by avoidance of the object or situation. The *Diagnostic and Statistical Manual of Mental Disorders, 5th edition* (DSM-5; American Psychiatric Association, 2013) identifies five types of specific phobias: animal, natural environment, blood-injection-injury, situational, and other.

Storm phobias fall within the natural environment type in DSM-5 (American Psychiatric Association, 2013), and are characterized by an excessive and disproportionate fear of severe weather conditions, such as thunderstorms and tornadoes, often accompanied with anticipatory anxiety, avoidant behaviours, and significant distress and/or functional impairment (Nelson, Vorstenbosch, & Antony, 2014). Approximately 2% of the population in the United States and Canada will experience a phobia of storms in their lifetime (Stinson et al., 2007). Furthermore, Watt and DiFrancescantonio (2012) suggested that because climate change is leading to more severe weather conditions, it is predicted that there will be an increase in fears related to severe weather. An early study on severe fear of storms found that onset is often related to exposure to a traumatic experience involving severe weather (i.e., classical conditioning) or through media exposure of severe weather (i.e., vicarious learning; Westefeld, 1996). Participants in this study described a number of associated symptoms, including constantly monitoring severe weather warnings, feeling highly anxious in the anticipation of the severe weather, and concerns about safety and thoughts that they could get injured or die during the weather event. Very few participants sought or even considered treatment (Westefield, 1996).

Treatment of Specific Phobias

Many experts agree that exposure to the feared object/situation is both necessary and sufficient for treating individuals with specific phobia (Hood & Antony, 2012). Although there are different forms of exposure therapy (e.g., imaginal exposure, interoceptive exposure, in vivo exposure), in vivo exposure has been found to be superior at reducing fear in this population (Emmelkamp & Wessels, 1974; Moscovitch, Antony, & Swinson, 2009). It consists of exposing individuals to their actual feared object/situation in real life. A review of studies on in vivo exposure therapy found that 80% to 90% of patients who completed treatment were able to complete a behavioural approach test (BAT; a behavioural measure of clinical change) at the end of treatment, and that most individuals showed gains that were maintained at a 6- to 14-month follow-up (Choy, Fyer, & Lipsitz, 2006). Although in vivo exposure is an effective treatment for specific phobias, it does have some limitations. Some individuals may find it undesirable because of the apprehension of having to face their feared object/situation, which may lead to them to avoid seeking treatment. Additional limitations include difficulty maintaining confidentiality if doing in vivo exposures out of the office, an inability to control variables such as weather conditions, and potential high costs (e.g., having to buy a plane ticket for exposure in flying phobia; Wiederhold & Weiderhold, 2005). To date, there are no controlled studies on exposure-based treatment for storm phobia.

Virtual Reality Exposure Therapy

Concerns about the inherent difficulty in exposing individuals to a feared stimulus may be overcome through the use of virtual reality (VR). VR provides a three-dimensional computer-generated environment that allows individuals to actively participate in a virtual world that adapts to the movement of their head and body motion (Wiederhold & Weiderhold, 2005). Individuals are able to experience auditory, visual and tactile stimuli (e.g., feeling the vibrations from the virtual thunder), which make it possible to immerse themselves in a computer-generated environment (Rothbaum, 2006). This sense of presence may make it possible for VR to simulate realities that are not typically available, such as thunderstorms, in a controlled environment.

VR exposure therapy is a variation of exposure therapy and has many advantages. It allows therapists to control aspects of the situation (e.g., thunder) and to have the flexibility to focus on variables that may cause more distress (e.g., repeated take offs and landings in the treatment of flying phobia). It also can be less time-consuming and expensive than in vivo exposure. Whereas in vivo exposure can require extensive planning, scheduling, and travel to different locations, VR exposure does not require the therapist or client to leave the office. Additionally, unlike in vivo exposure, VR exposure is better able to ensure client confidentiality because the therapy is done in the privacy of a therapist's office and thus avoids the potential for public embarrassment (Rothbaum, 2006; Wiederhold & Weiderhold, 2005). Research has suggested that VR exposure may help increase the number of people who seek treatment for phobias (Garcia-Palacios, Botella, Hoffman, & Fabregat, 2007). It has been found to be a more appealing option than the standard exposure therapy because individuals tend to feel safer and appreciate the innovative technology (Garcia-Palacios et al., 2007).

VR exposure therapy has been more extensively researched in the treatment of other specific phobias, such as acrophobia (i.e., fear of heights) and fear of flying, where it has been found to be equally as effective as in vivo exposure therapy (e.g., Emmelkamp et al., 2002; Krijn, Emmelkamp, Olafsson, & Biemon, 2004; Rothbaum et al., 2006). However, its use in the treatment of storm phobias has been limited. There has only been one known paper to date that has described the use of VR exposure treatment of storm phobia. A case study by Botella et al. (2006) described the treatment of a 70-year-old woman who had been suffering from storm phobia since childhood. She displayed many avoidant behaviours, such as locking herself in a closet with loud music when it would rain, and her fear interfered with many areas of her life. The treatment consisted of 7 sessions, including educational sessions, in vivo exposure using exploding balloons, and VR exposure. The VR environment consisted of 5 different landscapes: A desert, a threatening forest, an island, a snow-covered town, and a meadow. Each landscape could be modified to include different effects, such as rain or snow, and it would be modified according to the patient's anxiety level. Botella et al. reported promising results of the use of VR for treatment of storm phobia. The patient was able to confront all her feared scenarios by the end of treatment and the improvements were maintained at 6-month follow-up. She also found the treatment experience to be enjoyable and very useful. Based on this case study, it seems that VR therapy may be able to effectively treat individuals with storm phobia. However, an experimental study is needed in order to provide evidence for the efficacy of VR exposure therapy in treating storm phobia and to justify future research.

The Present Study

Findings from previous studies support the need for more research on the treatment of storm phobia. Although treatment research in this area is limited, there have been successful treatments for other specific phobias involving VR exposure. This study explored the efficacy of VR exposure therapy in the treatment of storm fears by comparing a one-session VR exposure treatment to treatment involving progressive muscle relaxation (PMR) and psychoeducation. Although PMR has been found to be an effective treatment for generalized anxiety (Conrad & Roth, 2007), it is not generally recommended for the treatment of specific phobia. Given that PMR is effective in reducing state anxiety, studies have previously used PMR as an active control condition to compare the effectiveness of exposure therapy (e.g., Mühlberger, Herrmann, Wiedemann, Ellgring, and Pauli, 2001). Mühlberger et al. compared VR exposure therapy to a control PMR therapy in people with a fear of flying, and found reduced fear in both groups. However, there was significantly greater fear reduction for those in the VR exposure group than for those in the PMR group. Thus, it was expected that in the present study, PMR would likely temporarily reduce storm-related anxiety, but to a lesser extent than would VR exposure therapy. Based on previous research, it was also predicted that there would be a reduction in storm-related anxiety posttreatment for individuals in both conditions, but that this reduction would be greater for those in the VR exposure condition, and that improvements would be maintained at a 30-day follow-up only for those in the VR exposure condition (Mühlberger et al., 2001).

Method

Participants

Participants were recruited from a large metropolitan city. Interested participants were invited to complete an online version of the *Storm Fear Questionnaire* (SFQ; Nelson et al., 2014). Individuals who scored 25 or above on the SFQ and were between the ages of 18 and 65 were invited to participate in the study, in exchange for $20 compensation.

Thirty-eight individuals participated in the study with random assignment to the VR exposure treatment (n = 20) and to the PMR treatment (n = 18). However, three participants in the VR treatment group did not complete treatment. Two experienced nausea and requested to stop after the pretreatment BAT and one stopped after step 5 of the treatment due to heightened fear. Both participants who dropped out due to nausea were excluded from analysis due to missing treatment and posttreatment BAT data. The participant who completed treatment up to step 5 was included in the analysis due to having begun treatment and having posttreatment BAT data. So, the final sample included 18 participants in each group.

Those in the VR exposure treatment had a mean age of 25.65 (SD = 7.81) and a mean storm fear age of onset of 7.94 (SD = 5.79). Those in the PMR treatment had a mean age of 29.47 (SD = 10.93) and a mean storm fear age of onset of 8.61 (SD = 8.84). There were 9 males and 9 females in each group and participants primarily identified as Asian (n = 14), White/European (n = 10), Black/Afro-Caribbean/African (n = 4), Hispanic/Latin American (n = 1), and biracial/multiracial/other (n = 6). Twenty participants were currently enrolled in an educational program and twenty-two participants reported being employed either part-time (n = 17) or full-time (n = 5). Finally, 34 out of the 36 participants completed the follow-up assessment, n = 17 from each group.

Measures

The *Storm Fear Questionnaire* (SFQ; Nelson et al., 2014) is a 15-item self-report measure assessing the severity of fear, anxiety, phobic avoidance and distress associated with storms and severe weather conditions. Participants indicate the extent to which each statement is true for them, using a scale from 0 (not at all true) to 4 (almost always true). A cutoff score of 25 was used in this study to determine whether participants had a high fear of storms. The cutoff score was determined by adding two standard deviations to the mean SFQ score of an unselected undergraduate student sample from the original study. The SFQ has high internal consistency (α = .95) and good convergent validity (Nelson et al., 2014). For this study, the SFQ was administered at three time points (screening, posttreatment, and 30-day follow-up). In the posttreatment version participants were asked to answer the questions based on what they would do/how they would feel now that they had completed treatment. Participants' SFQ score at screening, posttreatment, and follow-up were used as an indicator of treatment outcome over time.

The *Subjective Units of Distress Scale* (SUDS; Wolpe & Lazarus, 1966) is commonly used as a verbal rating of an individual's subjective fear/distress on a 100-point scale, where 0 reflects no fear or distress and 100 reflects the worst fear or distress one can imagine. It has been found to correlate with indices of autonomic arousal, such as heart rate and skin conductance level (Thyer, Papsdorf, Davis, & Vallecorsa, 1984).

The *Credibility/Expectancy Questionnaire* (CEQ; Devilly & Borkovec, 2004) is a self-report measure assessing the extent to which participants believe the treatment is credible and their beliefs about what they expect from the treatment. The CEQ consists of 6 questions, of which the first three measure credibility (e.g., "How logical does the course offered to you seem?") and the last three measure expectancy (e.g., "How much do you really feel that the course will help you to improve your functioning?"). The CEQ has shown high internal consistency (α = .79 to .90) and good test-retest reliability (r = .82).

Behavioural Approach Tests (BAT) are used as behavioural indicators of how long a participant can tolerate an anxiety-provoking stimulus. In this study, participants were exposed to a virtual thunderstorm using the *Virtually Better VR Environments* software. The BAT consisted of a series of ten steps of increasing difficulty, in which participants started with seeing a sunny blue sky and progressed to seeing a dark sky with heavy rain, wind, thunder and lightning every 5 seconds. Participants saw the thunderstorm on a head-mounted display, and heard the rain, thunder, and wind through built-in speakers. Participants were also able to experience vibration through their chairs, which were placed on a raised platform fitted with woofers that vibrated to the sound of thunder, lightning and wind. Participants were asked to perform each step for 30 seconds and then verbally report their level of anxiety using SUDS ratings at the end of each step. The BAT ended if the participant failed to perform one of the steps for 30 seconds or when the participant completed all ten steps. The BAT was completed once before treatment and once at the end of treatment in order to compare participants' level of anxiety from pre- to posttreatment. Participants' mean, peak, and final self-reported anxiety score during the pre- and posttreatment BAT were used as an indicator of treatment outcome in the analysis.

Apparatus

The VR environment that was used was developed by Virtually Better, Inc. and included visual, auditory, and motion simulation to provide a high level of immersion. The visual cues were presented using a head-mounted display with a head tracker that adapted to participants' field of view with each head movement. Visually, participants appeared to be in a house with a back and front yard that they could enter. The audio cues emanated from speakers that were built into a platform under the chair. The audio cues included sounds of thunder, rain and wind that would increase in volume when individuals stepped outside. A tactile vibrating platform was used to provide thunder simulation. Individuals were also given an interactive control that allowed them to navigate around the virtual environment. The researcher had full control over the weather in the virtual environment through the use of a monitor and keyboard, which also allowed the researcher to see what participants were seeing.

Procedure

Individuals who expressed interest in the study were emailed a link where they could complete the SFQ online to be screened for eligibility (i.e., a score of 25 or above). Those individuals who were eligible were invited to visit the laboratory where they were asked to provide informed consent. Following consent, they were asked to complete a 5-minute BAT to assess their initial fear, where they were exposed to a virtual thunderstorm. Participants were then randomly assigned to one of two treatment conditions: VR exposure or PMR and psychoeducation.

VR Exposure Condition

Participants in the VR exposure condition were first given a rationale for exposure therapy. They then completed a prolonged exposure to a virtual thunderstorm, which lasted approximately 1 hour or until the participant's fear had decreased to a mild level (i.e., the participant's fear had decreased to a SUDS rating of 25 or less). The VR exposure was conducted in a small dimly lit room, away from any external noise. Participants were asked to report their SUDS ratings every few minutes during the VR exposure. Participants went through a series of eight steps of increasing difficulty, including: (1) a sunny blue sky, (2) light rain with a darkening sky and thunder occurring in the distance, (3) moderate rain and a darkening sky, with thunder close by, (4) moderate rain and a darkening sky, with thunder close by and lightning every 10 seconds, (5) heavy rain and a dark sky, with immediate thunder, lightning every 10 seconds and strong wind, (6) heavy rain and a dark sky, with immediate thunder, strong wind and lightning every 5 seconds, (7) severe rain and a dark sky, with immediate thunder, strong wind and lightning every 5 seconds, (8) severe rain and a dark sky, with immediate thunder, strong wind, lightning every 5 seconds and a power outage. Participants were instructed to begin inside the house for each step and slowly make their way outside to the front yard at their own comfort level. Once participants felt comfortable moving onto the next step, they were instructed to make their way back inside the house, at which point their final self-reported SUDS score was recorded. Once the VR exposure had ended, participants were again asked to complete the same 5-minute BAT. They were then asked to complete the CEQ and the SFQ. Participants were contacted 30 days after their initial treatment session and asked to complete the SFQ for a third time.

PMR Condition

Participants in the PMR and psychoeducation condition were first given a rationale for the use of PMR in the treatment of anxiety disorders, as well as instructions in how to conduct the PMR exercises. This was followed by a session of PMR and focused breathing lasting about 30 minutes. PMR is a relaxation technique involving the tensing and relaxing of 16 muscle groups of the body (McCallie, Blum, & Hood, 2006). Participants received PMR in the same small dimly lit room where the VR exposure treatment was conducted. Following PMR, participants received psychoeducation about thunderstorms, which entailed reading an article with information about what a thunderstorm is and how it is develops. The information for the article was taken from a Wikipedia page entitled *"Thunderstorm"* (http://en.wikipedia.org/wiki/Thunderstorm). The information from this page was formatted to look like an academic journal article on thunderstorms. Once they had finished reading the article, participants were asked to complete the same 5-minute BAT, followed by the CEQ the SFQ. Participants were contacted 30 days after their initial treatment session and asked to complete the SFQ for a third time.

Statistical analyses

SPSS was used to analyze the data, with all statistical tests being two tailed and the significance level was set to $\alpha = .05$. Data were analyzed using a Mixed Model Analysis of Variance in which group by time interactions were examined. The between subjects factor was group (VR vs. PMR) and the within subjects factor was time (pretreatment vs. posttreatment vs. follow-up). Changes in storm-related anxiety, as measured by participants' score on the SFQ at screening, posttreatment and follow-up and participants' SUDS ratings during pre- and posttreatment BATs were examined. Participants' mean SUDS score, peak SUDS score, and final SUDS score (i.e., on step 10) during pre- and posttreatment BATs were used in the analyses.

Results

Treatment outcome

To determine whether both treatment groups had similar expectations about the credibility of the treatment they received, an independent-samples *t*-test was conducted to compare the CEQ in VR exposure and PMR conditions. There was no significant difference in CEQ scores between the VR exposure (M = - 0.93, SD = 12.78) and the PMR (M = - 8.20, SD = 12.92) groups, $t(34)$ = 0.17, *ns*.

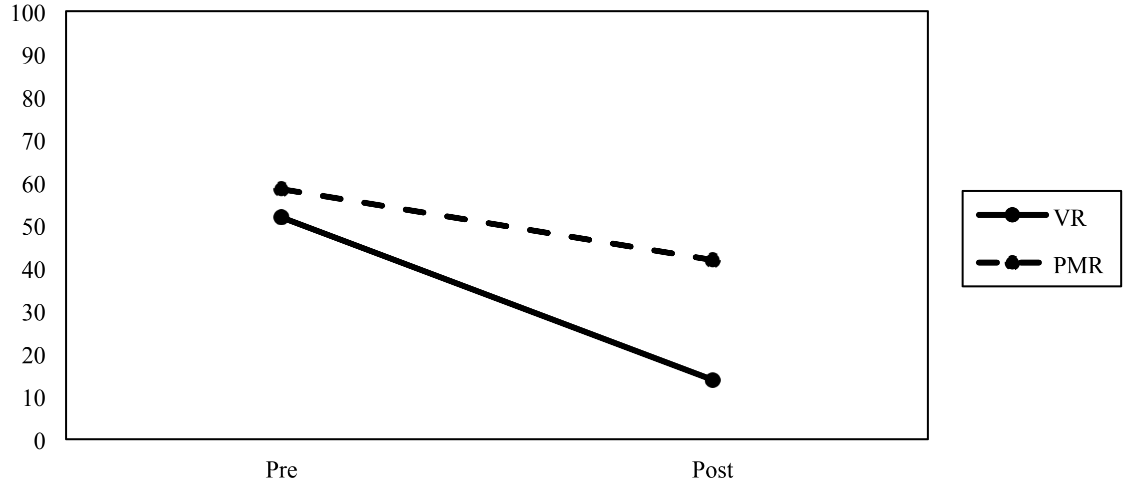

Figure 1. Mean SUDS ratings at pretreatment and posttreatment BATs. Main effect of time, $F(1,34) = 57.99$, $p < .001$; main effect of group, $F(1,34) = 8.58$, $p = .006$; time by group interaction, $F(1,34) = 8.86$, $p = .005$.

Significant main effects of time were found for mean, peak, and last reported SUDS ratings, such that posttreatment scores were lower than pretreatment scores (see Figures 1-3). Planned contrasts revealed significant main effects of group for mean, peak, and last reported SUDS ratings, such that the VR group reported lower overall SUDS ratings than the PMR group (see Figures 1-3). Significant treatment group by time interactions were also found for mean, peak, and last reported SUDS ratings, revealing greater reductions in SUDS ratings for the VR group than for PMR group (see Figures 1-3).

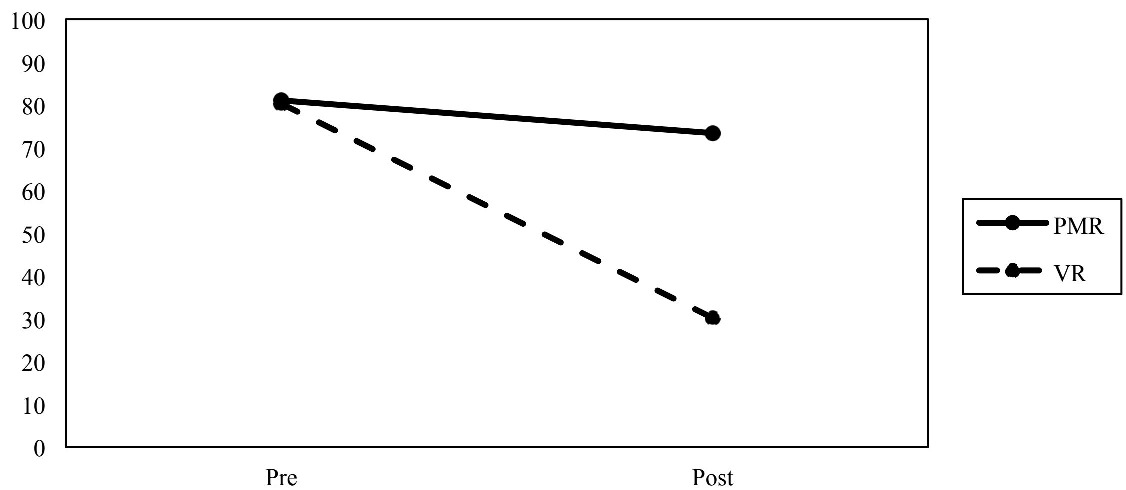

Figure 2. Peak SUDS ratings at pretreatment and posttreatment BATs. Main effect of time, $F(1,34) = 45.29$, $p < .001$; main effect of group, $F(1,34) = 8.17$, $p = .007$; time by group interaction, $F(1,34) = 24.42$, $p < .001$.

Posthoc *t*-tests revealed that there were no significant group differences in SUDS ratings for the pretreatment BAT. There were, however, significant group differences for mean, peak, and last reported SUDS ratings at posttreatment (see Table 1). Cohen's *d* effect sizes for mean, peak, and last reported SUDS ratings were 1.44, 1.58, and 1.53, respectively, indicating a strong effect of VR exposure relative to PMR.

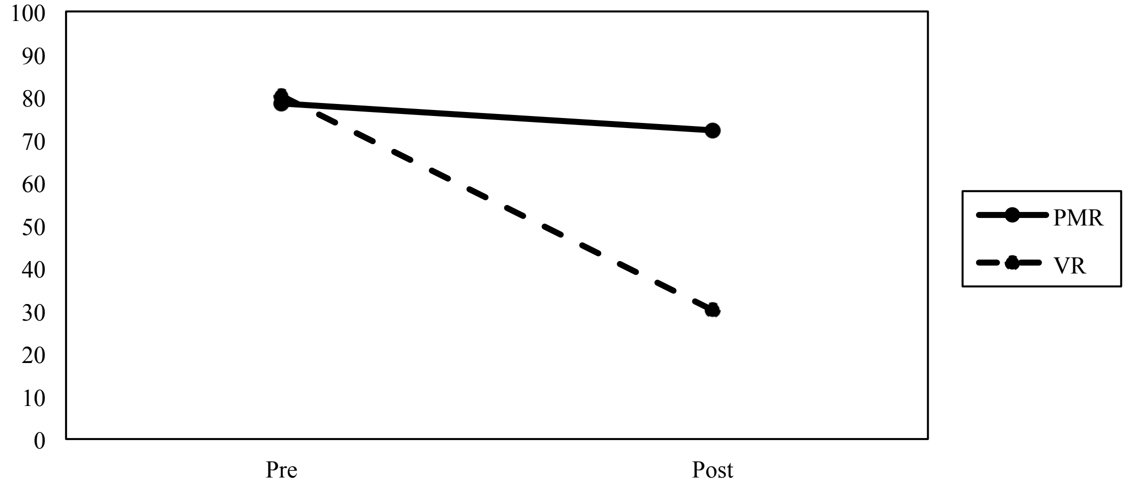

Figure 3. Last SUDS ratings at pretreatment and posttreatment BATs. Main effect of time, $F(1,34) = 43.97$, $p < .001$; main effect of group, $F(1,34) = 6.38$, $p = .016$; time by group interaction, $F(1,34) = 26.55$, $p < .001$.

Follow-up

A significant main effect of time was found for the SFQ (see Figure 4). Planned contrasts revealed a significant difference between pretreatment and follow-up scores. There was also a significant main effect of group, Cohen's $d = 0.72$. However, there was no significant time by group interaction for changes on SFQ scores between pretreatment and posttreatment or pretreatment and follow-up. An examination of group means indicated that self-reported fear of storms was reduced in both groups at follow-up, and that follow-up scores were lower for the VR group. However, there were no significant treatment group by time interactions for the SFQ at either posttreatment or follow-up.

Discussion

The purpose of this study was to examine the efficacy of VR exposure in the treatment of individuals with a fear of storms. To our knowledge, this is the first controlled study on the treatment of storm-related fears. A comparison of self-reported anxiety (SUDS) during pretreatment and posttreatment BATs between the VR exposure group and the PMR group revealed that both treatments resulted in reduced self-reported anxiety. This was expected because exposure therapy has consistently been found to cause attenuation of fear, and progressive muscle relaxation is used in various anxiety disorders in order to reduce anxiety symptoms (Conrad & Roth, 2007). However, there were significant interaction effects for mean, peak, and last score SUDS ratings, indicating that those in the VR exposure group had a greater reduction in self-reported anxiety than those in the PMR group, and with large effect sizes. These results suggest that although both interventions were effective in reducing anxiety, these effects were stronger for the VR group, as was hypothesized.

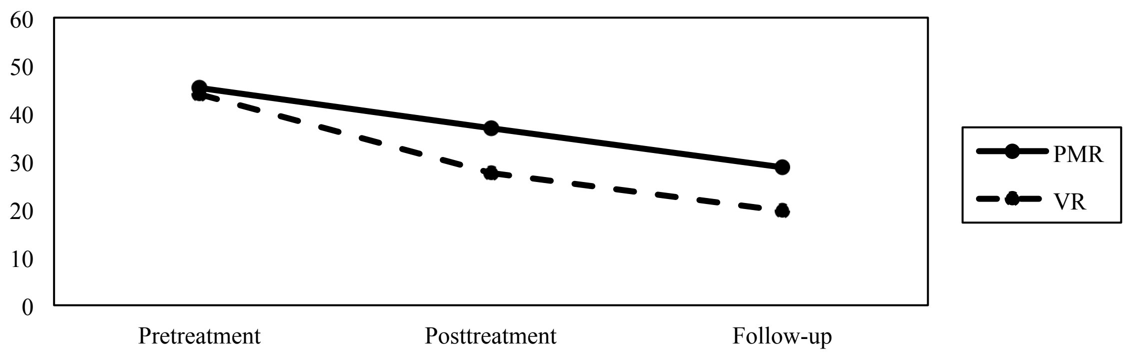

Figure 4. SFQ scores at pretreatment, posttreatment, and follow-up. Main effect of time, $F(2, 64) = 42.25$, $p < .001$; planned contrast of main effect of time between pretreatment and follow-up, $F(1,32) = 72.28$, $p < .001$, main effect of group, $F(1,32) = 4.12$, $p = .044$.

Table 1. Means, standard deviations, and simple main effects for pretreatment and posttreatment BATs between VR and PMR groups

Note. Significance levels based on t-tests with df = 17. BAT = behavioral approach test; VR =

	VR Mean (SD)	PMR Mean (SD)	Simple Main Effects (VS vs. PMR)
Pretreatment SUDS			
Mean	51.84 (20.40)	58.49 (23.31)	-0.91
Peak	80.22 (26.00)	81.00 (24.92)	-0.09
Last	80.22 (26.00)	78.50 (27.40)	0.19
Posttreatment SUDS			
Mean	13.89 (11.58)	41.87 (25.01)	-4.31**
Peak	30.17 (26.39)	73.33 (28.23)	-4.74**
Last	30.17 (26.39)	72.22 (28.66)	-4.58**
Simple Main Effects (Pretreatment vs. Posttreatment)			
Mean	6.94**	3.59*	
Peak	6.49**	2.05	
Last	6.49**	1.77	

virtual reality; PMR = progressive muscle relaxation; SUDS = subjective units of discomfort scale.
* $p < .01$, ** $p < .001$

Both groups reported similar treatment expectancy and credibility ratings after having been told that their respective treatments had been shown to be effective in the treatment of other disorders, but that they had never been tested in the treatment of storm phobia. This provides additional support for the efficacy of the VR intervention, as there was no differential effect of treatment expectancy between groups. These findings correspond with much of the research on VR in the treatment of fear of heights and fear of flying (Emmelkamp et al., 2002; Mühlberger et al., 2003; Rothbaum et al., 2006), which has found VR exposure to be an effective treatment in reducing anxiety and avoidant behaviours posttreatment. These findings also replicate the findings of Mühlberger et al. (2001), which found that both VR exposure and PMR reduced anxiety posttreatment in flight phobics, but that there were greater gains for those in the VR exposure group.

Analysis of the follow-up data revealed that a significant main effect of group with a medium effect size. Although there was no interaction between time and group, both groups appeared to maintain treatment gains at 30-day follow-up. This was expected for those in the VR exposure therapy group due to previous research that has found long-term treatment gains following VR exposure therapy (Mühlberger et al., 2003; Emmelkamp et al., 2002; Rothbaum et al., 2006). However, this was not expected for those in the PMR group, as PMR is not typically used alone in the treatment of phobias. It could be the case that those in the PMR group took what they learned from the relaxation training and applied it during anxiety-provoking situations, which would make them feel less anxious when confronted with a thunderstorm. It is also possible that these gains could be explained by repeated exposure during the BATs. This would also explain why the participants in the PMR group reported modest improvements, as they did experience some degree of exposure. However, this is speculative and further investigation is required to make more substantial claims about the long-term effects of VR exposure in the treatment of storm phobia.

Limitations

The findings from this study should be interpreted with some caution due to the small sample size. In addition, this was a nonclinical sample. However, with the exception of one single case report, the present study is the first to examine VR treatment for storm fears. Although the sample size is small, the findings from this study provide at least some support that VR exposure therapy is a promising approach in the treatment of storm phobia. Due to this small sample size there is also a limitation to the data analysis in the use of multiple comparisons (e.g., multiple correlations, *t*-tests), which may have resulted in inflated Type 1 error rates. There is research, however, suggesting that statistical corrections, such as Bonferroni corrections in cases of multiple analyses, should not be used due to the risk of unnecessarily inflating Type II error (Morgan, 2007; Rothman, 1990). It was thus decided that given the uniqueness of this study, being the first to examine the treatment of storm fears using VR in a controlled manner, the risk of Type 1 error was preferred over a greater risk of Type II error.

Another shortcoming to this present study was that the outcome measures did not assess fear and related behaviours during an actual thunderstorm. However, as this was a pilot study, these outcome measures were deemed to be the most feasible and were thought to provide the best assessment of anxiety reduction and behavioural change. In addition, 30 days may not have been a long enough follow-up period, considering that depending on the time of year, a thunderstorm may not have occurred within that time frame. Following up with participants to determine if treatment gains have long-term effects is crucial for determining whether the treatments were effective at reducing fears of true storms rather than virtual storms. Other studies have found VR exposure treatment gains up to a year later (Emmelkamp et al., 2002; Mühlberger et al., 2003; Rothbaum et al., 2006). If this were found to be the case for this present study, it would provide stronger evidence that VR exposure is a viable treatment option for storm fear.

Finally, although it is possible that having been exposed to the virtual thunderstorm environment would have effects on the subsequent BAT, this is a limitation with all research on exposure-based therapies that use active control conditions. The methodology used and the significance of the findings is consistent with previous research on exposure-based interventions.

Future directions

Future studies should focus on replicating the findings of this present study as this is the first controlled study on the treatment of storm phobia. Specifically, future studies should use a clinical sample diagnosed with specific phobia. In addition, future studies should include a third BAT at a follow-up time in order to have a behavioural measure of long-term treatment gains, and should include a longer follow-up period. Researchers should also include an in vivo behavioural assessment in order to assess treatment effects during real world thunderstorms. It would also be helpful to replicate this study in children, considering that storm phobia has an early onset.

In sum, the present study demonstrated that both treatment groups (VR exposure vs. PMR) experienced attenuation in self-reported anxiety at posttreatment, but that this reduction was more pronounced for those in the VR exposure treatment group. Taken together, these findings confirmed the main hypothesis that VR exposure to storms would result in greater reduction in self-reported anxiety. Investigation of follow-up data showed promise for long-term treatment gains in the use of both treatments, but further study is needed. These findings have allowed for more insight into storm phobia and offer VR exposure therapy as a promising approach in its treatment.

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Ethical Statement: The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, and its most recent revision. The Ethics Committee of [Institution] approved the research project (REB 2010-268).

Conflict of interests: The authors have no conflict of interest with respect to this publication.

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