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Advances in the application of virtual reality technology in psychiatric disorders

Zhao Wei[1,a], Zhang Yao[2,b,*], Hao Wanting[2,c], Fu Qiaorui[2,d], Zhao Li[2,e], Wu Yuting[1,f], Fan Yunchao[1,g], Chen Hongfang[3,h,*]

[1]Nursing College of Shaanxi University of Chinese Medicine, Xianyang, China
[2]The Military Medical Center of the First Affiliated Hospital of the Air Force Military Medical University, Xi'an, China
[3]General Affairs Department of Shaanxi Provincial Hospital of Traditional Chinese Medicine, Xi'an, China
[a]3435036125@qq.com, [b]12409858@qq.com, [c]934412731@qq.com, [d]752741790@qq.com
[e]709186073@qq.com , [f]484290293@qq.com, [g]2308073766@qq,com, [h]chf1695@163.com
**Corresponding author*

Abstract: *The application of virtual reality (VR) technology in the medical field has gradually gained attention in recent years, especially in the treatment of psychiatric disorders. With its immersive and highly controllable features, VR technology helps patients safely simulate and cope with real-life scenarios, thus promoting the effectiveness of psychotherapy. In this paper, we will review the progress of VR technology in multiple psychiatric disorders such as anxiety disorders, post-traumatic stress disorder (PTSD), depression, and schizophrenia. With technological advancements and the integration of multiple disciplines, VR will achieve more precise and personalized applications in mental health intervention, promoting innovation in treatment models.*

Keywords: *Virtual Reality Technology, Mental Illness, Psychotherapy, Treatment Model*

1. Introduction

Virtual Reality (VR) technology refers to a three-dimensional environment generated by computers, allowing users to interact with objects and scenes in the virtual world. By wearing a VR headset and holding a controller, users can enjoy an immersive experience. This sense of immersion makes VR an effective tool for psychological therapy[1],especially in exposure therapy and cognitive behavioral therapy, where it has significant applications. In recent years, the application of virtual reality (VR) technology in the fields of psychological counseling and psychotherapy has gradually attracted widespread attention[2]. Through creating immersive virtual environments, VR technology enables patients to confront and address their emotional and psychological issues in a safe space. Studies have shown that VR technology has demonstrated excellent efficacy in the treatment of various mental health issues[3]. Relevant studies project that by 2025, the burden of mental disorders in China will increase by 10%[4].Cognitive Behavioral Therapy (CBT) is a widely used psychological treatment method for mental disorders. The core concept of CBT is that an individual's emotions and behaviors are driven by their thought patterns (cognition). By identifying and changing negative cognitive patterns, CBT helps patients improve their emotions, modify their behaviors, thereby alleviating symptoms and enhancing their quality of life.

2. Application of VR in the Treatment of Anxiety Disorders

Anxiety disorder[5] is a common psychological disorder characterized by persistent tension, worry, and fear, which significantly impairs the daily life and social functioning of patients. Traditional treatment methods include cognitive behavioral therapy(CBT),medication, among others, but these approaches have limited effectiveness in some patients. In recent years, virtual reality (VR) technology, as an emerging therapeutic approach, has been gradually applied in the treatment of anxiety disorders [6], demonstrating excellent results and broad prospects. Exposure therapy [7] is an effective method for treating anxiety disorders, aiming to help patients reduce their anxiety responses by gradually exposing them to their sources of fear. VR technology provides a safe and controllable environment for exposure

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therapy. For example: 1) VR can create various virtual scenarios to simulate the fear-inducing situations faced by patients. These scenarios may include heights, confined spaces, social situations, and can be customized according to the patient's specific fears. 2) VR enables therapists to gradually increase the intensity of exposure based on the patient's comfort level and adaptability. For example, the patient can first observe the feared object in the virtual environment, and then gradually approach or interact with it. In the VR environment, the patient's responses (such as heart rate, breathing, etc.) can be monitored in real time. The therapist can adjust the treatment strategy based on these data and provide immediate support and guidance[4].Studies have shown[8] that using VR for exposure therapy can effectively reduce the anxiety levels of patients with social anxiety, specific phobias (such as acrophobia and aerophobia), etc. The advantage of VR lies in the fact that therapists can receive treatment conveniently and safely in the office. They can adjust the intensity of exposure by controlling the content and intervals, and can repeat the exposure as needed. They can also specifically repeat the exposure as required, and use special functions. This indicates that VR can provide a safe and controllable environment, helping patients gradually adapt to social scenarios in the real world.

2.1 social anxiety disorder

Social Anxiety Disorder (SAD)[9] is a common psychological disorder characterized by intense fear and avoidance behaviors in social situations, which significantly impacts the patient's daily life and social skills. VR combined with CBT (Virtual Reality Cognitive Behavioral Therapy) is gradually becoming an innovative and effective treatment method. By integrating virtual reality technology with traditional cognitive behavioral therapy, patients can gradually confront their social phobia in a safe and controllable environment, thereby achieving emotional regulation and psychological rehabilitation. Virtual Reality (VR)-based Cognitive Behavioral Therapy (CBT) combines traditional psychotherapy methods with advanced technological approaches, demonstrating numerous advantages. The following are some key advantages of combining VR with CBT: 1) Immersive experience: VR technology can provide a highly immersive environment[10], enabling patients to experience and confront their fears or anxieties within a safe virtual space. This sense of immersion can enhance the effectiveness of the treatment, as patients can practice coping strategies in a more realistic situation. 2) Safety: In virtual environments, patients can confront situations that may trigger anxiety or fear in real life without worrying about actual risks. This sense of safety enables patients to more boldly explore and process their emotions and responses[11]. 3) Personalized Treatment: VR combined with CBT can be tailored to the specific needs and conditions of each patient. Therapists can design specific virtual environments to address each patient's sources of fear or issues, thereby enhancing the targeted and effective nature of the treatment[12]. 4) Real-time feedback: The VR system can track the patient's reactions in real time and provide immediate feedback. This immediate feedback helps patients better understand their emotional responses and make adjustments during the treatment process[13]. 5) Enhancing Motivation: Compared to traditional face-to-face therapy, VR combined with CBT is often more engaging and interesting. Patients may be more willing to participate in this novel form of treatment, thereby enhancing their motivation and sense of participation in therapy. 6) Repeatability: Patients can repeatedly face the same environment in the virtual scenario for practice. This repetitiveness helps consolidate learning and coping strategies, enhancing patients' confidence and coping abilities. 7) Convenience: VR combined with CBT can be conducted in various environments. All that is needed is to equip with the corresponding devices, and patients can receive treatment at home or in the treatment center. This flexibility provides patients with greater convenience[14].

The implementation steps of VR-CBT: 1) Initial Assessment and Treatment Plan: The first step in treatment involves a detailed evaluation of the patient, including specific manifestations of social anxiety, the degree of fear toward social situations, and previous treatment experiences. Based on the assessment results, the therapist formulates a personalized treatment plan, clearly defining the treatment goals and expected outcomes. 2) Design of the virtual environment: The therapist will design the virtual environment based on the specific fear situation of the patient. For example, if a patient is afraid of talking to people at a party, a virtual environment can simulate a social gathering scene[15], featuring various characters and interaction environments. This design aims to allow the patient to experience realistic social interactions in a safe context. 3) Gradual Exposure and Real-time Feedback: Patients undergo gradual exposure in the virtual environment, starting with simple interactions in a small group [16].As therapy progresses, the complexity and challenges of the social environments are gradually increased. Throughout the process, therapists provide real-time feedback and support to help patients adjust their coping strategies and reduce anxiety. 4) Cognitive Restructuring: After each virtual experience, the therapist will discuss the patient's feelings and thoughts with them, helping them identify negative automatic thoughts and changing these thought patterns through cognitive

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restructuring. For example, if a patient feels that others' evaluations of them are very negative in the virtual scenario, the therapist will guide the patient to analyze the rationality of such thoughts and help them establish a more positive self-perception. 5) Social Skills Training: In addition to confronting fears, VR-CBT also includes training in social skills. Patients can practice social skills such as eye contact[17], listening skills and response strategies in a virtual environment. This practice can enhance patients' confidence in handling social situations in real life[18]. Foreign scholars have conducted a randomized controlled study on the effectiveness of Virtual Reality Exposure Therapy[19](VRET) and In Vivo Exposure Therapy[20]in the treatment of Social Anxiety Disorder (SAD).This study aims to compare the effectiveness of these two treatment methods, the patients' acceptance of them, and the long-term effects after treatment. The study recruited participants diagnosed with social anxiety disorder and randomly assigned them to two groups: one receiving VRET and the other receiving traditional in vivo exposure therapy. The study lasted for 12 weeks, during which each group of patients received the same treatment frequency and duration. During the treatment process, researchers used standardized assessment tools (such as the Social Anxiety Scale) to periodically evaluate patients' anxiety levels and social functioning. The research results show that both groups of patients exhibited significant reduction in anxiety symptoms at the end of the treatment. However, the patients in the VRET group experienced a greater reduction in anxiety levels in certain social situations, particularly when interacting with strangers and delivering in public speaking. Furthermore, patients in the VRET group generally reported that the virtual reality environment made them feel safer and more relaxed, enabling them to better comfront with their social phobia. This immersive experience enables them to feel a greater sense of control and participation during the treatment. During the 6-month follow-up after the treatment, improvements in social functioning and quality of life were sustained in the VRET group, whereas the improvements in the in vivo exposure therapy group diminished relatively quickly. This indicates that VRET may have certain advantages in promoting long-term treatment outcomes.

2.2 Generalized Anxiety Disorder

Generalized Anxiety Disorder[21](GAD) is a common psychological disorder characterized by persistent and excessive worry and anxiety, typically involving multiple aspects of life such as work, health, and interpersonal relationships. Virtual reality-based positive mindfulness therapy and virtual reality cognitive bias modification interpretation (VR-CBM-I) have shown significant therapeutic effects. VR-CBM-I[22] significantly improved patients' anxiety, depression, positive thinking, and emotional regulation abilities, while also enhancing treatment adherence. VR-CBM-I enhanced patients' perception of positive explanations for events, reduced negative explanations, and increased the number of patients who were capable of providing positive explanations for the events. Due to the interactive and immersive nature of VR, VR-CBM-I is more effective than CBM-I in reducing state anxiety and emotional responses to stressors. Compared to CBM-I, VR-CBM-I significantly reduced patients' anxiety levels and emotional responses to stressors to a greater extent, thanks to the interactive and immersive features of VR[23].The advantage of using VR to treat anxiety disorders lies in the fact that although you know the scenes are electronically simulated, the thoughts and behaviors feel real. Because our thoughts and behaviors feel real, we are more likely to confront scenarios that are more terrifying than the real world. Research[24] indicates that exposure to natural environments can improve emotional states and effectively prevent or reduce mental health issues. For patients, it may be difficult to access natural environments during hospitalization[25], and VR technology can offer the following benefits. VR technology can simulate highly realistic virtual natural environments, thereby solving this problem. VR technology provides patients with highly realistic virtual natural environments through head-mounted displays. Patients can immerse themselves in panoramic images, and the head-mounted displays will also play soothing music[26].

3. The application of VR in the treatment of post-traumatic stress disorder (PTSD)

Post-Traumatic Stress Disorder[27](PTSD) is a psychological disorder caused by experiencing or witnessing traumatic events. These events may include war, natural disasters, serious accidents, sexual assault, or other life-threatening situations[28].For the treatment of PTSD, traditional prolonged exposure therapy[29] involves having patients gradually and imaginatively revisit and narrate the traumatic event in a graded manner. The core of this method lies in gradually exposing patients to the traumatic memories, which helps them reduce their avoidance and fear of these memories, thereby facilitating emotional processing and psychological recovery[30].Although this method is effective in many cases, it also has some limitations, such as patients may become overly anxious during the

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imagination process and thus have difficulty fully engaging in the treatment. Some researchers have applied virtual reality (VR) technology to survivors of the "9/11" incident[31] to assist them in dealing with post-traumatic stress disorder (PTSD) and related mental health issues. This study aimed to use the immersive experience of VR to allow survivors to gradually confront trauma-related memories in a safe environment, thereby facilitating the emotional processing and psychological recovery. The results showed that after the treatment, the PTSD symptom scores of the participants significantly decreased, indicating an enhanced ability to adapt to traumatic memories. Following VR treatment, the participants' emotional regulation abilities were improved, enabling them to more effectively cope with trauma-related anxiety and fear. Research indicates that VR-assisted trauma exposure therapy can effectively reduce PTSD symptoms. A study on veterans showed[32] that after VR treatment, the frequency and intensity of patients' traumatic recollections significantly decreased, and emotional stability improved.

4. The Application of VR in the Treatment of Depression

Depression is a common mental health disorder, characterized by persistent low mood, reduced interest in daily activities, lack of energy, and negative thinking. It not only affects the emotional state of patients but also may have a severe impact their social interactions, work, and quality of life. A foreign study[33] used VR technology to enable patients with depression to express sympathy and comfort to themselves, implementing "Compassion-Focused Therapy" (CFT).This therapy aims to help patients cultivate self-compassion and alleviate negative emotions stemming from self-criticism. During the specific implementation process, patients are placed in a virtual environment where they can interact with their past experiences and respond to their emotional distress in a gentle and understanding manner: VR technology can be used for the emotional regulation training of patients with depression. By immersing themselves in a positive virtual environment, patients can experience a sense of pleasure, thereby improving their emotional state. The research results showed that patients who underwent VR compassion-focused therapy demonstrated significant improvements in self-compassion, emotion regulation, and depressive symptoms. Domestic research has reported[34] that providing virtual reality attention training to patients with brain injuries can improve their attention and cognitive functions. Compared with traditional attention training methods, training through virtual reality can better stimulate patients' interest and increase their participation in rehabilitation training, thereby achieving better rehabilitation outcomes. The relevant study[35] investigated the effects of virtual reality-based attention training combined with sertraline on cognitive function and the fractional amplitude of low-frequency fluctuations (fALFF) in brain regions of adolescent patients with depressive episodes. The control group was given sertraline hydrochloride tablets, while the experimental group received sertraline combined with virtual reality-based attention training. The treatment course lasted for 6 months, with consistent medication dosages in both groups. The results showed that, compared to pre-treatment, both groups had reduced HAMD scores and increased MMSE scores after treatment ($t = 3.20, 3.12, -3.06, -3.27$, respectively; all $P < 0.05$). Compared with the control group after treatment, the experimental group had lower HAMD scores and higher MMSE scores ($t = 2.75, -2.34$, respectively; both $P < 0.05$). This suggests that virtual reality-based attention training combined with sertraline can improve the severity of depression in adolescent patients with depressive episodes, enhance neuronal activity intensity in the brain, and improve cognitive function.

5. The Application of VR in the Treatment of Schizophrenia

Schizophrenia[36][37] is a severe mental disorder, typically characterized by severe distortions in thinking, emotions, and behavior. It affects an individual's cognitive functions, emotional responses, and social interactions. Freeman D et al.[38] used VR technology to simulate real-life therapy for delusions of being victimized and achieved remarkable therapeutic effects. The core of this research lies in utilizing a virtual reality environment to provide patients with a safe and controllable space, where they can confront and deal with the fears and anxieties related to persecutory delusions. The ability to interact can potentially cause patients to encounter significant challenges in their daily lives. In this study, the research team designed a series of virtual scenarios to simulate the social situations that patients might encounter in their daily lives, such as interacting with others in public places. Patients wear VR headsets [39] to immerse themselves in these scenarios while receiving guidance from therapists. After multiple treatments, patients reported a significant decrease in the frequency and intensity of their persecutory delusions in post-treatment assessmentsm. Many patients indicated that their sense of fear had diminished, allowing them to view their thoughts more rationally. The patient's

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anxiety and depression symptoms have also been alleviated, and their overall emotional state has improved. Moreover, as the delusional symptoms have lessened, the patient's confidence in social interactions has increased, enabling them to participate in daily activities more actively. Patients with schizophrenia often suffer from severe symptoms such as auditory hallucinations, and medication is typically one of the conventional interventions. However, research has shown that combining medication and virtual reality (VR) technology[40] may offer more assistance to patients with schizophrenia. Virtual reality technology can simulate various sounds and scenarios, helping patients better understand and manage their auditory hallucination experiences. For example, through VR, patients can learn to identify the triggers of auditory hallucinations and learn to cope with these sounds to reduce the distress these hallucinations cause. Avatar therapy is a new type of VR treatment method aimed at creating a virtual "Avatar" image, allowing patients to engage self-exploration and emotional expression in a safe environment. This therapy is particularly suitable for the mental health field and can help patients address various psychological issues, such as anxiety and depression[41].In avatar therapy, patients can express themselves by customizing their virtual avatars, which can reduce anxiety when confronting real-life issues. This immersive experience enhances patients' self-awareness, facilitate the release and processing of emotions. In addition, the use of VR technology for social skills training has a positive impact on improving the social functions of patients with schizophrenia[42]. They can engage in conversations with virtual characters, simulate face-to-face interactions, or handle scenarios of daily life challenges. This training helps patients gradually regain their social skills and self-care abilities, enhancing their adaptability in the real society. Furthermore, VR game interactions not only assess patients' social abilities but also motivate them to engage in social skills training through engaging game mechanics[43].During these interactions, patients receive immediate feedback, which helps them recognize their social behaviors and reactions. Through continuous practice and feedback, patients can gradually improve their social skills, build self-confidence, and reduce social anxiety. Furthermore, the immersive experience of VR games enhance patients' engagement, making them more willing to participate in training, thereby improving the therapeutic outcomes. The research results of Smith et al.[42] indicate that, compared with the control group, patients with schizophrenia who received virtual reality (VR) interview training significantly demonstrated in terms of interview confidence and employment rates. This study placed patients in simulated interview environments, allowing them to practice interview skills in a stress-free setting and learn how to communicate effectively with potential employers. This training method has had a positive impact on the emotional state of the patients, with many participants reporting reduced anxiety and increased confidence, making them more willing to actively seek job opportunities. Ultimately, the patients who received VR interview training showed a significant improvement in their subsequent employment rates survey, indicating that this innovative training method has practical effects in promoting the career development of patients with schizophrenia[44].

6. Challenges and Limitations in VR Applications

Although VR has achieved considerable success in anxiety disorders, trauma and stress-related disorders, schizophrenia, and depression, there are still shortcomings. First, technical limitations and device accessibility: High-quality VR equipment is typically expensive, which restricts their wide application in clinical practice. This makes it impossible for some patients to access this treatment method. Second, individual differences: Patients may have significantly different responses to VR treatment. Some patients may feel comfortable in the virtual environment, while others may feel uneasy or scared, which makes it more complicated to develop personalized treatment plans. Although VR technology is continuously advancing, some users still experience discomfort during use, such as motion sickness or anxiety, which can affect treatment outcomes. The patient's psychological state and acceptance of the technology may affect the treatment outcome. For some patients, traditional face-to-face therapy may be more effective. Third, lack of standardization: Currently, there is a lack of unified standards and guidelines for VR therapy, which leads to less standardized application in clinical practice and affects the consistency and reliability of the treatment. The optimal VR treatment course and frequency have not yet been determined, and more research is needed to design effective treatment plans. Fourth, limitations in research methodology and insufficient sample size: Many studies on VR therapy have small sample size and lack large-scale randomized controlled trials, which affects the generalizability and reliability of the results. Although some studies have shown positive effects in the short term, long-term outcomes remain insufficiently evaluated, and more long-term follow-up studies are still needed.

Future research could focus on the following directions: First, technological innovation: As

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technology advances, the availability and user experience of VR devices will continue to improve, potentially reducing discomfort and increasing the acceptance of treatment. Second, innovation in treatment models, personalized treatment: Develop personalized VR treatment plans based on patient characteristics to enhance treatment effectiveness. Third, multidisciplinary collaboration: Integrating knowledge from psychology, computer science, medicine, and other fields to promote the application of VR technology in the field of mental health.

In conclusion, VR shows promising prospects in mental health treatment, but it is necessary to systematically address the current deficiencies in technology, individual differences, standardization, and research evidence. In the future, with continuous technological advancements and in-depth research, the application of VR in the treatment of mental disorders will become more widespread. More clinical trials and long-term follow-up studies are needed to verify the efficacy and safety of VR treatment.In addition, VR therapy will integrate artificial intelligence and big data analysis to develop personalized treatment plans, further enhancing its application value in the field of mental health. This will enable its wide-scale application in clinical practice. Through continuous research and technological innovation, VR is expected to provide more effective treatment options for more patients.

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