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Research Article

Comparison of the Effectiveness of Virtual Reality-Based Schema Therapy and Process-Oriented Cognitive Behavioral Therapy in Managing Post-Traumatic Stress Disorder in Individuals with Severe Physical Injuries

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Objective: Individuals with severe physical injuries often face significant psychological challenges, including anxiety, depression, and post-traumatic stress disorder (PTSD), which complicate their recovery process. Recognizing the need for targeted interventions, this study aimed to compare the effectiveness of virtual reality-based schema therapy (VRST) and process-oriented cognitive behavioral therapy (PB-CBT) in managing PTSD among these individuals.

Method: The study addressed a gap in the literature by focusing on the unique demands of a military and clinical population in a challenging recovery context. A quasi-experimental design with a pretest, a posttest, and a control group was employed. The statistical population consisted of patients visiting the Shafieieh Clinic in Zanjan, Iran. Sixty individuals diagnosed with PTSD (based on DSM-5 criteria) were selected through convenience sampling and then randomly assigned to three groups: 20 participants received VRST, 20 received PB-CBT, and 20 formed a control group (waiting for treatment). Using a validated PTSD checklist, pretest and posttest assessments were conducted, ensuring reliable measurement of symptom changes.

Results: The findings indicated that both treatment groups demonstrated significant improvements in PTSD symptoms compared to the control group ($p < 0.05$); however, no statistically significant difference was observed between the VRST and PB-CBT groups ($p>0.05$).

Conclusion: The study underscores the importance of employing innovative, technology-enhanced interventions in managing trauma-related disorders and provides a basis for further research to explore the nuances of these therapeutic models.

Keywords: Severe physical injuries, Post-traumatic stress disorder, Virtual reality-based schema therapy, Process-oriented cognitive behavioral therapy, Health.

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Extended Abstract

Background and Objectives

Individuals with severe physical injuries—such as spinal cord damage, amputations, or extensive bone and muscle trauma—experience not only profound functional impairments but also significant psychological distress, including anxiety, depression, and post-traumatic stress disorder (PTSD). PTSD is characterized by intrusive memories, nightmares, avoidance of trauma-related cues, negative changes in cognition and mood, and heightened arousal. These symptoms can disrupt rehabilitation efforts, intensify pain, and undermine quality of life. A reciprocal relationship exists: untreated PTSD may exacerbate chronic pain, while unaddressed physical impairments can deepen psychological suffering. Despite this interplay, conventional rehabilitation often separates physical and mental health interventions, leaving a gap in integrated care for individuals facing both severe injury and PTSD. Two emerging therapies show promise for addressing this gap. Schema therapy delivered via virtual reality (VR-ST) pairs schema-focused techniques with immersive environments that safely expose patients to trauma-related stimuli, facilitating reprocessing of maladaptive beliefs. Process-based cognitive-behavioral therapy (P-CBT) extends beyond symptom reduction by targeting underlying biopsychosocial processes—such as experiential avoidance, cognitive rigidity, and emotional dysregulation—through mindfulness, emotion regulation, and trauma-focused cognitive restructuring. This study aimed to compare the relative effectiveness of VR-ST and P-CBT in reducing PTSD severity and its specific symptom clusters (Intrusion, Avoidance, Negative Cognitions/Mood, Hyperarousal, Emotional Numbing) among adults with severe physical injuries.

Materials and Methods

A quasi-experimental, pretest–posttest design with a no-treatment control group was implemented at a rehabilitation clinic in Zanjan, Iran, from May to September 2024. Sixty adults (ages 18–65) diagnosed with PTSD per DSM-5 criteria and recovering from severe physical injuries requiring hospitalization were recruited via convenience sampling. Exclusion criteria included concurrent psychotherapy, unmanaged substance use, severe cognitive impairment, or comorbid major psychiatric disorders. After providing informed consent, participants were randomly assigned to one of three groups (n=20 each): VR-ST, P-CBT, or control.

Participants in the VR-ST group completed twenty-one weekly 50-minute sessions facilitated by licensed clinical psychologists. VR-ST sessions followed a manualized schema therapy model adapted to an immersive virtual platform: patients encountered simulated trauma-related scenarios, identified and challenged maladaptive core beliefs, and practiced adaptive coping responses. The P-CBT group received eighteen weekly 50-minute sessions delivered by equally experienced clinicians following a standardized process-based manual. P-CBT targeted underlying cognitive and emotional processes through guided mindfulness exercises, trauma-focused cognitive restructuring, and graduated real-world exposure to previously avoided memories or situations. Therapist adherence was monitored through weekly supervision.

The primary outcome was PTSD severity measured by the PTSD Checklist for DSM-5 (PCL-5). Participants completed the PCL-5 at baseline (pretest) and immediately after the final session (posttest). The PCL-5 is a 20-item self-report inventory aligned with DSM-5 symptom clusters. Demographic and injury-related data were collected at baseline. Statistical analyses used SPSS version 27. After confirming normality (Shapiro–Wilk), homogeneity of variances (Levene's test), and equality of covariance matrices (Box's M), a multivariate analysis of covariance (MANCOVA) compared posttest PCL-5 scores across groups, controlling for baseline scores. Bonferroni-adjusted post hoc tests

identified pairwise differences, and partial eta squared quantified effect sizes.

Results

All sixty participants completed the study, and baseline characteristics (age, gender, injury type, and pretest PCL-5 scores) did not differ significantly among groups. MANCOVA revealed a significant overall group effect on posttest PCL-5 scores after controlling for pretest scores (Pillai's Trace = 0.58, $F(10, 98) = 4.08$, $p < 0.001$, partial $\eta^2 = 0.29$). Both VR-ST and P-CBT groups demonstrated significant reductions in total PTSD severity compared to control ($p < 0.001$), with large within-group effect sizes (partial $\eta^2 > 0.30$). No significant difference emerged between VR-ST and P-CBT in overall PCL-5 change scores ($p = 0.38$).

When examining symptom clusters, VR-ST led to a larger mean decrease in Intrusion (mean $\Delta = -4.15$, SD = 2.15) compared to P-CBT (mean $\Delta = -3.05$, SD = 2.28), but this difference narrowly missed statistical significance after correction ($p = 0.06$). P-CBT produced a slightly greater reduction in Avoidance (mean $\Delta = -2.45$, SD = 1.70) than VR-ST (mean $\Delta = -2.35$, SD = 1.62), also not significant ($p = 0.08$). Both interventions achieved equivalent improvements in Negative Cognitions/Mood (–4.05 vs. –3.85; $p = 0.42$), Hyperarousal (–3.40 vs. –3.20; $p = 0.44$), and Emotional Numbing (–3.96 vs. –3.95; $p = 0.99$). No adverse events, such as VR-induced cybersickness or therapy-related destabilization, were reported. Treatment fidelity exceeded 90%.

Discussion and Conclusion

These findings indicate that both VR-ST and P-CBT effectively reduce PTSD symptoms in physically injured patients. VR-ST's immersive exposure likely facilitated habituation to trauma cues, producing marginally greater reductions in Intrusion symptoms. Safe engagement with simulated trauma content may have accelerated extinction of conditioned fear responses. P-CBT's emphasis on targeting underlying processes—such as experiential avoidance and cognitive inflexibility—likely promoted behavioral reengagement and produced slightly larger improvements in Avoidance behaviors. Both modalities yielded comparable reductions in Negative Cognitions/Mood, Hyperarousal, and Emotional Numbing, suggesting that shared therapeutic mechanisms (mindfulness, cognitive restructuring, and emotional regulation) effectively address these core symptom clusters across both approaches.

Although overall effectiveness did not differ significantly between VR-ST and P-CBT, the pattern of symptom-specific improvements aligns with theoretical expectations: VR-ST's experiential platform addresses intrusion more directly, while P-CBT's process-driven approach reduces avoidance by fostering gradual engagement with avoided experiences. The absence of severe adverse events—despite minimal systematic monitoring for VR-related discomfort—suggests both interventions are well tolerated in this population, although broader assessments of tolerability are warranted.

Limitations include convenience sampling at a single clinic, which may limit generalizability; participants amenable to VR may differ in technological literacy or motivation. The quasi-experimental design, lacking an active placebo, cannot rule out unmeasured confounding variables. The absence of long-term follow-up precludes assessment of durability of treatment effects and potential relapse. Although no adverse events were recorded, systematic evaluation of VR-related risks was not conducted.

Both virtual reality-based schema therapy and process-based cognitive-behavioral therapy significantly reduce PTSD symptom severity among individuals with severe physical injuries. While VR-ST appears to offer an advantage for mitigating intrusive memories through immersive exposure, and P-CBT shows strengths in reducing avoidance by targeting underlying processes, their overall effectiveness is comparable. Clinicians should consider patient-specific

symptom profiles, resource availability (e.g., VR equipment, therapist training), and practical constraints when select ing interventions. Future research should employ randomized sampling, incorporate follow-up assessments to evalu ate long-term outcomes, and investigate moderating factors such as gender, injury severity, and baseline dissociation. Incorporating these evidence-based, integrative approaches into rehabilitation settings may enhance psychological resilience and improve the overall quality of life for this high-need population.

Introduction

Individuals who suffer from severe physical injuries, such as spinal cord injuries, amputations, or severe damage to bones and muscles, experience significant changes in their daily lives (Strøm, 2022). These injuries, often resulting from traumatic accidents, severe illnesses, or violence, have consequences that extend beyond physical limitations. These consequences can severely affect an individual's ability to perform simple daily activities (Haldemann et al., 2024) and significantly reduce their quality of life. In addition to physical challenges, individuals often face psychological difficulties such as anxiety, depression, and post-traumatic stress disorder (PTSD), which can complicate the recovery process and increase pain and suffering (Johnson et al., 2025).

Post-traumatic stress disorder (PTSD), as defined in the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), refers to a severe and prolonged psychological reaction to a traumatic event. These events may include life-threatening incidents, serious injuries, or sexual assault, and exposure to them can occur directly, through observation, or through close association with a victim. Symptoms of PTSD include intrusive memories (flashbacks), distressing nightmares, avoidance of triggers, persistent negative changes in mood and cognition, and increased arousal, which may manifest as irritability, exaggerated startle responses, or sleep disturbances (American Psychiatric Association, 2013). These symptoms can disrupt all aspects of an individual's life, making it difficult to engage in relationships, work, or social activities. The interplay between physical injuries and psychological trauma is complex. Chronic stress and intense emotions associated with PTSD can exacerbate physical conditions. For example, PTSD-related stress may increase the severity of chronic pain or cause muscle tension, making physical recovery more challenging. This vicious cycle highlights the need for comprehensive treatments that address both physical and psychological aspects simultaneously (Hoppen et al., 2021). Ignoring these aspects may reduce the effectiveness of physical rehabilitation and increase the risk of chronic problems.

The psychological impact of severe physical injuries is often accompanied by feelings of helplessness, isolation, and reduced social engagement. Individuals with physical injuries may experience feelings of worthlessness and hopelessness, which can disrupt their participation in daily activities and exacerbate emotional distress. Many of these individuals feel they have lost their purpose or identity, especially if the injuries prevent them from returning to previous roles such as employment or caregiving. This loss of independence often creates a cycle of emotional isolation, deepening their psychological suffering (Duckworth & Iezzi, 2010). Therefore, therapeutic interventions that simultaneously address physical and mental health are essential. These interventions can improve physical rehabilitation while enhancing the quality of life, enabling individuals to play more effective roles in society (Bryant, 2019). However, there are still research gaps related to the needs of individuals facing both PTSD and severe physical injuries. The lack of comprehensive and specialized treatment protocols hinders better outcomes in their recovery

(Grant et al., 2024).

Schema therapy based on virtual reality (VR) is an emerging and innovative approach in psychology that combines advanced technology with psychological principles, opening new horizons in the treatment of trauma-related disorders. This method utilizes controlled and simulated environments to facilitate exposure to traumatic experiences and their reprocessing (Wiebe et al., 2022). The unique feature of this approach is the addition of an experiential dimension to traditional schema therapy, enabling more active patient engagement with maladaptive schemas and the practice of adaptive responses in realistic, safe environments. The use of VR technology enables patients to revisit and reconstruct deeply rooted negative beliefs stemming from trauma in simulated situations, while learning more effective coping skills and enhancing resilience. These interactive and personalized environments create a unique and profound experience that can positively impact psychological recovery and quality of life. Although preliminary evidence supports the effectiveness of this approach (Deng et al., 2019; Botella et al., 2015), further and more extensive research is needed to evaluate its efficacy, particularly among individuals facing the dual challenges of PTSD and severe physical injuries.

In contrast, process-based cognitive-behavioral therapy (P-CBT), an evolution of traditional cognitive-behavioral therapy, is grounded in process-based therapy (PBT) a framework that identifies and targets the underlying biopsychosocial processes (e.g., cognitive rigidity, experiential avoidance, and maladaptive emotional responses) driving psychological problems, rather than focusing solely on diagnostic categories. Process-based therapy aims to tailor interventions to each individual by addressing the specific mechanisms that maintain distress. Building on this foundation, P-CBT is an innovative approach to managing PTSD that focuses on these underlying psychological and emotional processes, rather than merely symptom reduction (Hayes & Hofmann, 2018). This method emphasizes tailoring and personalizing therapeutic interventions based on trauma history, emotional responses, and the unique needs of each individual, offering a more personalized and targeted therapeutic experience. Techniques such as mindfulness, emotional regulation, and trauma-focused cognitive restructuring are designed to identify and modify the underlying processes that sustain PTSD symptoms. These techniques encourage individuals to examine maladaptive thought and behavior patterns and develop more adaptive coping strategies (Ciarrochi et al., 2024). Through this approach, therapy not only focuses on alleviating symptoms but also promotes self-awareness, enhances psychological flexibility, and reduces emotional harm. Although this approach has proven effective in general populations, including individuals with various trauma histories (Ong et al., 2025), research on its application in individuals with severe physical injuries and its impact on physical and psychological rehabilitation remains limited, highlighting the need for further investigation.

Given the complex psychological needs of individuals with both PTSD and severe physical trauma, and the limited evidence available on integrated interventions for this population, this study is essential. Comparing two innovative therapies; virtual reality-based schema therapy and process-based cognitive-behavioral therapy; can provide valuable insights into which approach is more effective in improving both psychological outcomes and overall quality of life. The results of this study can guide clinicians in selecting more effective, personalized treatment plans for this underserved and high-risk population. This research is essential because individuals with both PTSD and physical trauma often require more than standard treatments. Many current interventions fail to address their complex psychological needs.

Innovative, personalized therapies may offer better engagement and outcomes. This study seeks to help identify effective and applicable approaches for this vulnerable population.

Research Hypotheses

- Virtual reality-based schema therapy will significantly reduce PTSD symptoms in individuals with severe physical injuries compared to baseline.
- Process-based cognitive-behavioral therapy will significantly reduce PTSD symptoms in individuals with severe physical injuries compared to baseline.
- There will be a significant difference between the two approaches in their effectiveness, as measured by greater reductions in PTSD symptoms and psychological functioning scores with one approach.

Method

This quasi-experimental study utilized a pretest-posttest design with a control group to compare the effectiveness of Virtual Reality-Based Schema Therapy (VRST) and Process-Based Cognitive-Behavioral Therapy (PB-CBT) in managing symptoms of post-traumatic stress disorder (PTSD) among individuals with severe physical injuries. The study was conducted from May to September 2024 at the Shafiyeh Clinic in Zanjan. A convenience sample of 60 participants diagnosed with PTSD based on DSM-5 criteria was selected and randomly assigned to three groups: VRST group (20 participants), PB-CBT group (20 participants), and a control group (20 participants). The control group did not receive any treatment during the study period but was provided access to treatment after the study concluded to ensure ethical considerations were met. A power analysis using G*Power software (version 3.1) indicated that a minimum of 54 participants (18 per group) was required to detect a medium effect size ($f = 0.25$) with 80% power and a significance level of 0.05. This study exceeded this minimum to account for potential sample attrition.

Inclusion criteria included a clinical diagnosis of PTSD, the presence of severe physical injuries (individuals with injuries requiring hospitalization or significant medical intervention), age between 18 and 65 years, and willingness to provide written informed consent. Exclusion criteria included concurrent participation in other psychological treatments, comorbid psychiatric disorders (such as schizophrenia or bipolar disorder), severe cognitive impairment, substance use disorders not in remission for at least six months, and inability to attend sessions or complete follow-ups.

The VRST protocol was designed based on Young's schema therapy model and consisted of 21 weekly sessions (50 minutes each), utilizing virtual reality technology to simulate trauma-related situations and restructure maladaptive schemas. The PB-CBT protocol included 18 weekly sessions (50 minutes each) focusing on cognitive restructuring, exposure therapy, and mindfulness-based techniques. Both interventions were delivered by licensed clinical psychologists with over five years of experience in trauma-focused therapies.

Data were analyzed using SPSS version 27. Descriptive statistics (mean, standard deviation, frequency) were used to summarize participant characteristics and baseline data. Multivariate analysis of covariance (MANCOVA) was employed to compare changes in PTSD symptoms across the three groups over time. Bonferroni post-hoc tests were used to identify specific differences between groups.

Ethical statement

Ethical considerations included obtaining informed consent, maintaining confidentiality, ensuring voluntary participation, and adhering to international standards for research ethics. Participants were recruited through therapist referrals, and comprehensive information about the study's objectives and methods was provided to them.

Instruments

Post-Traumatic Stress Disorder Checklist (PCL-5): A 20-item self-report tool fully aligned with the diagnostic criteria for PTSD in DSM-5. This instrument uses a 5-point Likert scale (1 to 5), with scores from 0 to 80. The PCL-5 includes five subscales: Intrusion (Criterion B), Avoidance (Criterion C), Negative Alterations in Mood and Cognition (Criterion D), Hyperarousal (Criterion E), and Emotional Numbing (F1), each corresponding to the symptom clusters of PTSD in DSM-5. The Cronbach's alpha coefficient for the English version is 0.95, and for the French version, it is 0.94. The convergent validity of the English version is reported as 0.89. In Iran, Varmaghani et al. (2018) standardized this scale for the Iranian population. Exploratory factor analysis revealed that the PCL-5 has a five-factor structure in Iranian culture. The scale demonstrated high internal consistency, with a Cronbach's alpha of 0.92. Significant correlations between the scores of this scale and Mississippi Scale for Combat-Related PTSD (M-PTSD) scores indicated appropriate convergent validity (0.74), while correlations with resilience scores demonstrated satisfactory divergent validity (0.46). In the current study, the Cronbach's alpha coefficient for the total scale was 0.92, and for the subscales of Intrusions (B), Avoidance (C), Negative Alterations in Cognition and Mood (D), Hyperarousal (E), and Emotional Numbing (F1), the values were 0.90, 0.85, 0.70, 0.74, and 0.72, respectively.

The following sections describe the treatment protocols for Virtual Reality-Based Schema Therapy and Process-Based Cognitive-Behavioral Therapy in detail.

Table 1: Protocol for Schema Therapy with the Addition of Virtual Reality (Mousavi Asl et al., 2013)

Session	Intervention Description
Session 1	Explanation of the schema model in simple and clear language for the patient, including how schemas and coping styles are formed.
Session 2	Assessment of the patient's problems and exploration of dysfunctional life patterns, along with completion of the Multidimensional Life Questionnaire.
Session 3	Hypothesis generation regarding schemas, their identification, and labeling.
Session 4	Identification of coping styles and the patient's temperament, with the use of virtual reality in the assessment phase.

Session	Intervention Description
Session 5	Conceptualization of the patient's problem according to the schema therapy approach and compilation of all information obtained during the assessment phase.
Session 6	Examination of objective evidence supporting or refuting schemas based on past and present evidence.
Session 7	Attribution of evidence supporting schemas to childhood experiences and dysfunctional parenting styles.
Session 8	Dialogue between the schema side and the healthy side of the patient, and learning responses from the healthy side.
Session 9	Preparation and development of educational schema cards for use when encountering schema-triggering situations.
Session 10	Recording schema activation in daily life and noting when schemas are triggered.
Session 11	Explanation of the rationale for using experiential techniques and conducting imaginary dialogues.
Session 12	Strengthening the concept of the "Healthy Adult" in the patient's mind, identifying unmet emotional needs, and fighting against the schema.
Session 13	Providing an opportunity for the patient to identify their feelings toward their parents and their unmet needs by them.
Session 14	Helping the patient release blocked emotions related to the traumatic event and providing a supportive environment.
Session 15	Finding new solutions for communication and abandoning avoidance and overcompensation coping styles.
Session 16	Creating a comprehensive list of problematic behaviors, setting change priorities, and defining therapeutic targets.
Session 17	Using virtual reality to simulate problematic situations and confront the most challenging behaviors.
Session 18	Practicing healthy behaviors through role-playing and completing tasks related to new behavioral patterns.
Session 19	Reviewing the advantages and disadvantages of adaptive and maladaptive behaviors.
Session 20	Overcoming obstacles to behavior change.
Session 21	Teaching strategies for maintaining the modified schema.

Table 2. Description of Process-Based Therapy Sessions (Ong et al., 2022)

Therapeutic Process	Details
Creating the Therapeutic Network (Sessions 1 and 2)	**Initial Network Formation:** The therapist and patient collaboratively create an initial network of the patient's problems based on the patient's self-reports and therapeutic discussions. **Functional Analysis:** Each node and connection in the network is carefully analyzed to determine its role in creating and maintaining the patient's core issue. **Identifying Self-Reinforcing Subnetworks:** Parts of the network that are automatically reinforced without external stimuli are identified. These subnetworks often form the core of the patient's problem. **Setting Therapeutic Goals:** By identifying self-reinforcing subnetworks, the therapist can establish specific therapeutic goals. The primary aim is to disrupt these subnetworks and change the patient's thought and behavioral patterns.

Therapeutic Process	Details
	Greater Flexibility Toward Personal Standards: The therapist and patient discuss the outcomes of tasks completed in previous sessions.
Deeper Examination of the Therapeutic Network (Session 3)	**Attention Control:** Through play therapy, the therapist and patient explore new solutions to the problem.
	Reinforcing Positive Changes: The therapist reinforces and stabilizes positive changes in the patient's behavior.
	Increased Awareness of Personal Standards: The patient realizes that many of their behaviors are influenced by personal standards that often operate unconsciously.
	Greater Flexibility: By recognizing these standards, the patient can respond more effectively using cognitive defusion techniques (from ACT).
Developing New Skills to Manage Thoughts and Behaviors (Session 4)	**Tracking Outcomes:** The patient notices that changes in their behavior have led to positive outcomes in their life, which strengthens their motivation to continue therapy.
	Homework Exercises: The therapist assigns exercises to reinforce positive behaviors in the patient's daily life.
	Feeling Empowered: By applying therapeutic techniques, the patient feels more empowered in their life, which helps them sustain positive changes.
Transitioning from a Maladaptive to an Adaptive Network (Sessions 5 to 6)	**Important Decisions:** The patient begins to make important life decisions based on the insights gained, reflecting increased self-confidence and self-awareness.
	Effectively Coping with Reactivation of the Old Network: Despite progress, the patient's old network of thoughts and feelings occasionally reactivates. However, they are able to cope with these challenges using their new skills.
	Reviewing Recorded Experiences: This activity considers the patient's new therapeutic goals and helps the therapist better track their progress.
Redefining Goals (Session 7)	**Reinforcing Initial Goals:** Reviewing and summarizing the patient's goals and achievements.
	Setting New Goals: Based on the patient's progress, new therapeutic goals are set to address emerging challenges and support continued personal growth.
	Distancing from Negative Thoughts and Feelings: This skill helps the patient become less influenced by negative thoughts and emotions and better manage their emotional responses.
Focusing on Maintaining New Behaviors and Enhancing Quality of Life (Sessions 8 to 11)	**Creating a More Balanced Life Structure**: The patient strives to achieve a better balance between work, personal life, and leisure activities.
	Purposeful Actions: The patient acts more intentionally in their decision-making and actions.

Therapeutic Process	Details
Balancing Values and Reality (Sessions 12 to 15)	**Reviewing Attention Control and Mindfulness Skills:** These skills help the patient better control their attention and stay present in the moment. **Focusing on Core Values:** The patient learns to identify which values are currently a priority and focuses on them rather than trying to do everything. **Reviewing Useful Strategies:** Examining strategies that have been effective for the patient. **Areas of Success:** Identifying situations where the patient has successfully applied these strategies. **Generalizing Strategies:** Finding ways to apply these strategies in various life situations.
Strengthening Achievements and Planning for the Future (Sessions 16 to 18)	**Evaluating Effectiveness:** Assessing the long-term success of the strategies. **Progress and Strengths:** Identifying the patient's progress and strengths gained during therapy. **Areas Needing Reinforcement:** Highlighting areas where the patient still needs to work harder. **Sustaining Changes:** Focusing on maintaining and continuing positive changes in the long term.

Results

Initially, the demographic characteristics are reported. Table 3 presents the demographic characteristics (age, gender, education level, marital status, and type of physical injury).

Table 3. Demographic Characteristics of Research Participants by Intervention Type

	Demographic Characteristic	Control Group (n = 20)	Virtual Reality-Based Schema Therapy Group (n = 20)	Process-Based Cognitive-Behavioral Group (n = 20)
	Age (Mean ± SD)	36.35 ± 12.5	32.24 ± 89.4	34.22 ± 12.5
Gender	Male	50% (10)	60% (12)	55% (11)
	Female	50% (10)	40% (8)	45% (9)
Education Level	Below Diploma and Diploma	20% (4)	30% (6)	25% (5)
	Bachelor's Degree	60% (12)	50% (10)	55% (11)
	Master's Degree	20% (4)	20% (4)	20% (4)
Marital Status	Married	30% (6)	40% (8)	35% (7)
	Single	70% (14)	60% (12)	65% (13)
Type of Physical Injury	Bone Fracture	30% (6)	40% (8)	35% (7)
	Burn	40% (8)	30% (6)	35% (7)
	Cut and Tear	30% (6)	30% (6)	30% (6)

As can be seen in Table 3, the compared groups (process-based cognitive-behavioral, virtual reality-based schema therapy, and control group) are homogeneous in terms of demographic characteristics and type of physical injury.

Table 4 presents the descriptive statistics (mean and standard deviation) of the research variables in the pre-test and post-test stages in the three groups.

Table 4. Descriptive Statistics of Research Variables by Pre-test and Post-test

Variable	Group	Pre-test (M ± SD)	Post-test (M ± SD)
Intrusion	VR-Based Schema Therapy	16.55 ± 2.68	12.40 ± 2.79
	Process-Based CBT	17.25 ± 3.04	13.35 ± 3.61
	Control Group	15.65 ± 3.06	15.75 ± 3.02
Avoidance	VR-Based Schema Therapy	7.00 ± 2.02	4.65 ± 1.59
	Process-Based CBT	7.05 ± 1.64	4.60 ± 1.63
	Control Group	5.70 ± 1.89	5.75 ± 1.71
Negative Changes in Mood and Cognition	VR-Based Schema Therapy	13.25 ± 3.09	9.20 ± 2.23
	Process-Based CBT	14.40 ± 2.18	10.75 ± 3.49
	Control Group	10.50 ± 2.41	10.70 ± 1.83
Hyperarousal and Restlessness	VR-Based Schema Therapy	12.70 ± 2.92	9.30 ± 1.83
	Process-Based CBT	13.35 ± 2.34	10.05 ± 2.66
	Control Group	11.60 ± 2.77	12.15 ± 2.83
Emotional Numbing	VR-Based Schema Therapy	16.30 ± 3.98	12.35 ± 2.60
	Process-Based CBT	16.85 ± 3.57	12.00 ± 3.46
	Control Group	14.50 ± 2.39	14.00 ± 2.15
PTSD Symptoms (Total Score)	VR-Based Schema Therapy	65.80 ± 11.25	47.90 ± 6.84
	Process-Based CBT	68.90 ± 7.90	50.75 ± 8.89
	Control Group	57.95 ± 6.00	58.35 ± 5.61

Based on the information in Table 4, differences are observed between the mean scores of the pre-test and post-test in the experimental and control groups. Process-based cognitive-behavioral therapy and virtual reality-based schema therapy were able to change the mean scores of post-traumatic stress disorder symptoms in the post-test stage.

Then, multivariate analysis of covariance was used. For this purpose, the assumptions, including the normality of the distribution of scores, homogeneity of variances, and homogeneity of regression slopes,

were first examined. To evaluate the normality of the distribution of variables, the Shapiro-Wilk test was used, and the results showed that the distribution of dependent variables in the pre-test and post-test tages in the experimental and control groups is not significant($p<0.05$).

Therefore, it can be concluded that the distribution of scores is normal. Also, the assumption of homogeneity of variances was checked using Levene's test, and due to the non-significance of the statistic of this test for the dependent variables ($p<0.05$), the assumption of equality of variances of the experimental and control groups was confirmed. In addition, the results of the M Box test to examine the equality of variance-covariance matrices of internet addiction and high-risk behaviors in the experimental and control groups showed that the calculated value of M Box is equal to 1.30 and its significance level is $p=0.121$, which is not statistically significant. This finding confirms the equality of variances of the dependent variables. Also, regarding the assumption of homogene ity of regression slopes, the results of the F interaction for the group × pre-test of post-traumatic stress disorder symptoms showed that the regression slopes of the pre-test and post-test of this variable in the experimental and control groups are not significant ($F=1.28$, $p=0.285$). As a result,considering the observance of the assumptions of covariance analysis, the use of this test is ap propriate for data analysis.

Table 5. Results of Multivariate Analysis of Covariance to Compare the Mean Scores of the Post-test of Dependent Variables with Pre-tests Controlled, in the Experimental and Control Groups

Test	Value	F Value	Hypothesis df	Error df	Significance	Effect Size
Pillai's Trace	0.58	4.08	10	98	0.001	0.29
Wilks' Lambda	0.44	4.85	10	96	0.001	0.33
Hotelling's Trace	1.20	5.64	10	94	0.001	0.37
Roy's Largest Root	1.14	11.19	5	49	0.001	0.53

As shown in Table 5, the four multivariate analysis of covariance tests are statistically significant. Therefore, the experimental and control groups are significantly different in at least one dependent variable in the post-test stage. The reported effect sizes for these indices also reflect the intervention's considerable contribution to explaining changes in the dependent measures. Given the convergence of findings across these tests, it can be concluded that the intervention produced generally favorable and meaningful changes in the studied variables, with a high level of practical effectiveness.

Subsequently, the Bonferroni post hoc test was calculated. Table 6 shows the results of comparing the mean scores of the post-test of the dependent variables in the experimental and control groups through the mentioned method.

Table 6. Results of Bonferroni Post Hoc Test to Compare the Adjusted Means of Dependent Variables in the Post-test Stage in the Experimental and Control Groups

Group 1	Group 2	Statistical Indicators		
		Mean Difference	Standard Error	Significance
Virtual Reality-Based Schema Therapy	Process-Based Cognitive-Behavioral Therapy	-2.85	2.29	0.655
Virtual Reality-Based Schema Therapy	Control	-10.45	2.29	0.001
Process-Based Cognitive-Behavioral Therapy	Control	-7.60	2.29	0.005

According to the results in Table 6, the difference in scores between the virtual reality-based schema therapy group and the process-based cognitive-behavioral therapy group is not significant ($p > 0.05$). However, the scores of the virtual reality-based schema therapy group and the control group, as well as the scores of the process-based cognitive-behavioral therapy group and the control group, are significant ($p < 0.05$). Therefore, it can be concluded that the effectiveness of virtual reality-based schema therapy and process-based cognitive-behavioral therapy does not differ significantly.

Discussion and Conclusion

The main objective of this study was to investigate the effectiveness of virtual reality–based sche-ma therapy (VR-ST) and process-based cognitive-behavioral therapy (P-CBT) in managing post-traumatic stress disorder (PTSD) among individuals with severe physical injuries. Three hypotheses were examined, each analyzed in light of the empirical findings.

Although both interventions incorporate mindfulness and cognitive restructuring, VR-ST and P-CBT differ fundamentally in their therapeutic mechanisms. VR-ST combines traditional schema therapy with immersive, simulated environments; patients actively engage with trauma-related scenarios under therapist guidance, enabling direct modification of entrenched schemas through experiential exposure (Peters et al., 2022; Rizzo & Shilling, 2017). In contrast, P-CBT applies a process-based framework by targeting the underlying cognitive and emotional processes—such as experiential avoidance, cognitive rigidity, and maladaptive emotional responses—that sustain PTSD symptoms (Hayes & Hofmann, 2018; Ciarrochi et al., 2024). Thus, VR-ST's primary mech-anism is schema activation and correction via simulated exposure, whereas P-CBT focuses on identifying and modifying the biopsychosocial processes nderlying trauma symptoms.

Consistent with prior schema-therapy research (Khosravi et al., 2012; Naderi et al., 2015; Mousavi Asl et al., 2014), our results confirm that VR-ST significantly reduces overall PTSD severity. The immersive VR environment facilitates repeated, controlled confrontation with trauma-related

cues, accelerating habituation to intrusive memories. Patients reported fewer spontaneous flashbacks and decreased distress when recalling traumatic events—findings consistent with Crary's (2020) emphasis on simulated exposure, enhancing a sense of mastery. By identifying and challenging maladaptive schemas in vivo, VR-ST fosters deeper cognitive-emotional integration than traditional exposure alone.

P-CBT also produced significant reductions in PTSD symptoms, corroborating findings from Li et al. (2022), Biki and Yaser (2024), Javid Namin and Ghamari (2021), and Merati et al. (2018). By integrating mindfulness and experiential elements, P-CBT addresses not only explicit thoughts and behaviors but also the hierarchy of emotions in PTSD—where primary emotions such as fear and anxiety dominate and secondary emotions like guilt or helplessness are suppressed (Bohus et al., 2020; Psyc et al., 2012). Patients learned to reinterpret physiological arousal and intrusive sensations as meaningful signals, enhancing emotional regulation and reducing symptom severity. P-CBT's structured gradual engagement with avoided experiences (rather than relying solely on simulated exposure) cultivates emotional flexibility, self-compassion, and sustainable psychological growth (Held et al., 2023).

A detailed examination of symptom-cluster changes reveals differences aligned with each intervention's core mechanisms. VR-ST yielded greater decreases in intrusive memories and flashbacks, likely due to the immersive habituation that VR affords (Rizzo & Shilling, 2017). Patients repeatedly confronted memory triggers in a safe, controlled setting, facilitating extinction of conditioned fear responses. P-CBT produced larger reductions in avoidance behaviors by explicitly targeting experiential avoidance and cognitive rigidity; patients were coached to approach previously avoided thoughts and contexts gradually, resulting in more consistent behavioral reengagement. Both interventions demonstrated comparable improvements, as each integrates mindfulness—either embedded within VR scenarios for VR-ST or taught explicitly in P-CBT—to downregulate physiological arousal and reframe maladaptive beliefs (Bohus et al., 2020; Ciarrochi et al., 2024). Therefore, while VR-ST excels at reducing intrusive phenomena and P-CBT at diminishing avoidance tendencies, both converge effectively on hyperarousal and negative cognitions by promoting present-moment awareness and cognitive restructuring.

Although no statistically significant difference emerged between VR-ST and P-CBT in total PTSD symptom reduction, this result must be interpreted with caution. Statistical non-significance does not indicate equivalence; the sample size and convenience sampling may have limited power to detect small differences. Nevertheless, both interventions share core therapeutic principles—mindfulness, schema or process restructuring, and emotional regulation—which likely contributed to their comparable effectiveness. Their shared elements (present-moment focus, relaxation, awareness of thought/behavior patterns) and strong therapeutic alliance (Prochaska & Norcross, 2009)

appear to underlie similar improvements in emotional regulation and quality of life.

Convenience sampling represents a key limitation: participants were recruited based on availability and willingness, introducing potential selection bias and restricting generalizability to the broader population with severe physical injuries. Individuals who volunteered for VR or specialized psychotherapy may differ systematically (e.g., in motivation, technological literacy, or socioeconomic status) from those who did not participate. Additionally, the absence of a follow-up assessment precludes conclusions about the long-term sustainability of treatment gains and the potential for symptom relapse or differential durability between VR-ST and P-CBT. Although no adverse events or dropout rates were systematically recorded, future studies should monitor and report tolerability articularly for VR-based interventions where cybersickness or emotional overwhelm may occur.

To address these limitations, future investigations should use randomized or stratified sampling across multiple treatment centers to ensure a more representative cohort and reduce selection bias. Incorporating a follow-up group, assessed at 3, 6, and 12 months post-intervention, would clarify the maintenance of therapeutic gains and identify any relapse trajectories. Examining moderator variables—such as gender and severity/type of physical injury (e.g., spinal cord injury vs. limb amputation)—could reveal differential responsiveness to VR-ST versus P-CBT. Stratifying by these moderators in adequately powered trials will determine whether men and women, or patients with specific injury severities, benefit more from a particular modality, thereby enabling personalized treatment recommendations.

Clinicians should assess each patient's dominant symptom profile to guide intervention selection. For individuals whose primary challenge is intrusive memories and flashbacks, VR-ST's immersive exposure can facilitate rapid habituation and cognitive-emotional integration. Conversely, for patients whose chief barrier is avoidance—manifested as refusal to reengage in daily activities—P-CBT's process-focused strategies may be prioritized, teaching gradual exposure to avoided thoughts or contexts while fostering emotional flexibility and self-compassion. Integrating P-CBT's process-identification and mindfulness modules into VR-ST protocols could simultaneously address multiple symptom clusters, thereby enhancing overall efficacy. Finally, resource availability must inform modality choice: VR-ST requires specialized equipment and training, whereas P-CBT can be delivered with minimal technological demands, making it accessible in lower-resource settings. By aligning therapeutic approaches with individual symptom patterns and practical constraints, practitioners can optimize outcomes for this high-need population.

In summary, both VR-ST and P-CBT effectively reduced PTSD symptoms in individuals with severe physical injuries. VR-ST demonstrated a relative advantage in alleviating Intrusion symptoms, while

P-CBT showed greater impact on Avoidance behaviors. Both interventions achieved comparable improvements in Hyperarousal and Negative Cognitions & Mood, reflecting their shared emphasis on mindfulness and cognitive restructuring. These outcomes underscore that, although structurally different, VR-ST and P-CBT converge on several foundational mechanisms—particularly reducing negative emotional reactions and enhancing coping abilities—thereby improving overall quality of life.

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