

The Effectiveness of Embodied Emotional Exposure Therapy in Reducing Symptom Severity and Somatic Pain in Post-Traumatic Stress Disorder: A Limit-Cycle Framework

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Abstract

Background and Objective: Post-traumatic stress disorder (PTSD) frequently involves persistent somatic symptoms and pain, in addition to psychological distress, which can substantially impair daily functioning. Emotion-embodiment-focused exposure therapy within a limit-cycle framework conceptualizes somatic pain as arising from dynamic interactions among emotional processes, bodily experiences, and the nervous system, potentially perpetuated by self-sustaining cycles. This study investigated the effectiveness of this therapeutic approach in reducing symptom severity and somatic pain in individuals with PTSD.

Methods: A quasi-experimental pretest–posttest control-group design with a three-month follow-up was employed. Participants were recruited from individuals with PTSD attending Sedaye Zendegi Clinic in Tehran during the Iranian calendar year 1404 (2025–2026). Diagnoses were established through clinical interviews based on DSM-5 criteria conducted by a clinical psychologist and a psychiatrist. Forty participants were randomly allocated to the experimental or control group. The final sample comprised 18 participants in the experimental group and 20 in the control group. Pain outcomes were assessed using the Brief Pain Inventory (BPI), and the data were analyzed using repeated-measures analysis of variance (ANOVA).

Results: The intervention produced significant reductions in pain severity, pain interference, and total BPI scores in the experimental group. Significant group-by-time interactions were observed across all outcome measures. Bonferroni post hoc comparisons further indicated that the improvements were maintained at the three-month follow-up. These findings suggest that the intervention may facilitate sustained reductions in somatic symptoms and pain among individuals with PTSD.

Conclusion: Emotion-embodiment-focused exposure therapy within a limit-cycle framework appears to be a promising approach for reducing somatic symptoms and pain associated with PTSD. Its potential therapeutic mechanisms may include reduced emotional avoidance, modulation of physiological arousal, and regulation of maladaptive neuro-emotional cycles. Further research is warranted to establish the robustness of these effects and clarify the mechanisms underlying treatment response.

Keywords: Exposure Therapy, Limited cycle, Embodiment, Emotion, somatic symptoms and Pain, Post-Traumatic Stress Disorder

Introduction

Post-traumatic stress disorder (PTSD) is a major trauma-related disorder that develops after direct or indirect exposure to traumatic events, such as war, natural disasters, violence, severe accidents, sexual abuse, and other life-threatening situations. According to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision (DSM-5-TR), PTSD is characterized by four major symptom clusters: intrusion symptoms involving recurrent re-experiencing of the traumatic event, avoidance of trauma-related stimuli, negative alterations in cognition and mood, and alterations in arousal and reactivity (American Psychiatric Association, 2022). Although PTSD is classified as a mental disorder, research evidence indicates that its consequences extend beyond cognitive and emotional functioning and may involve a broad range of somatic, physiological, and neurobiological alterations.

The significance of this issue becomes more apparent when the substantial burden of PTSD in the general population and among high-risk groups is considered. Population-based studies in the United States have estimated lifetime PTSD prevalence at approximately 6%–8%, although estimates vary according to the population studied, diagnostic criteria, and assessment methods (Kessler et al., 2017). Prevalence is considerably higher in certain high-risk populations, including military veterans, refugees, and survivors of violence and sexual abuse. A systematic review and meta-analysis by Ng, L. C., Stevenson et al. (2020) found that the pooled prevalence of probable PTSD in sub-Saharan African regions affected by war was approximately 30%, compared with 8% in regions not affected by war or armed conflict. These findings highlight the substantial burden of PTSD in conflict-affected populations, although estimates from sub-Saharan Africa should not be generalized to all conflict-affected settings. In Iran, a systematic review and meta-analysis by Imani et al. (2024) estimated the pooled prevalence of PTSD at 31.87%. Given the substantial heterogeneity among the included studies, this estimate should be interpreted cautiously. Nevertheless, these findings underscore the importance of addressing the clinical and therapeutic consequences of PTSD, particularly those dimensions that may receive less attention in conventional interventions.

One important dimension of PTSD involves somatic symptoms and pain. Research has shown that PTSD is associated with a broad range of physical complaints (Lipowski, 1988; Henningsen et al., 2018). Individuals with PTSD may experience musculoskeletal pain, headaches, widespread pain, chronic fatigue, sleep disturbances, gastrointestinal problems, palpitations, dizziness, muscle tension, and other somatic symptoms. In some cases, medical findings or the severity of the original physical injury may not fully explain these complaints. They may persist even after the initial threat has subsided (Raja, 2020). Accordingly, bodily experiences in PTSD cannot be regarded merely as secondary consequences that are separate from the core processes of the disorder.

These somatic symptoms and pain may contribute to functional impairment, reduced quality of life, increased medical consultations, greater healthcare utilization, and substantial associated costs (Henningsen et al., 2018; Raja, 2020). Moreover, persistent pain and other somatic symptoms may complicate PTSD treatment because individuals must contend not only with traumatic memories and trauma-related stimuli but also with unpleasant bodily sensations that may themselves serve

as reminders of danger. Accordingly, persistent somatic symptoms and pain constitute an important component of the clinical presentation of PTSD and warrant direct therapeutic attention.

The relationship between PTSD and chronic pain has also been described as bidirectional. O'Connor et al. (2023) reported that individuals with PTSD experience higher rates of chronic pain and related symptoms than the general population, including muscular pain, sleep disturbances, and other somatic complaints. Conversely, Krimov-Zeinberg et al. (2024) suggested that persistent somatic symptoms and pain may exacerbate avoidance, increase physiological arousal, and contribute to the maintenance of PTSD symptoms. In addition, a systematic review and meta-analysis by Lunkenheimer et al. (2023) examined the prevalence and incidence of PTSD and PTSD symptoms among individuals with chronic somatic diseases, highlighting the relevance of trauma-related symptoms in populations living with chronic physical illness. Taken together, these findings suggest that trauma, emotion regulation, physiological arousal, and bodily experiences are connected through complex and potentially bidirectional processes.

Despite this evidence, many conventional therapeutic approaches continue to focus primarily on processing traumatic memories and reducing PTSD-related avoidance, while somatic symptoms and chronic pain receive less attention as direct treatment targets (American Psychiatric Association, 2022). Consequently, even when some psychological symptoms improve, physical complaints and chronic pain may persist. This discrepancy between the reduction of psychological symptoms and the persistence of bodily symptoms highlights the need to examine the underlying mechanisms of bodily experience in PTSD and to develop interventions that directly address this dimension of the disorder.

To explain this phenomenon, contemporary neurobiological models emphasize the complex interactions among the central nervous system, the autonomic nervous system, emotion, and cognitive processing. In contrast to traditional perspectives that regarded pain solely as a consequence of tissue damage, current models conceptualize pain and other somatic symptoms as multidimensional experiences arising from the integration of sensory, emotional, and cognitive information in the brain (Apkarian et al., 2005; Raja, 2020). From this perspective, the brain does not merely receive pain signals; through the continuous interpretation and prediction of bodily information, it also plays an active role in shaping and maintaining the experience of pain (Wiech, 2016).

This perspective is consistent with neuroimaging findings. Brain structures such as the amygdala, hippocampus, insular cortex, anterior cingulate cortex, and prefrontal cortex are involved in overlapping processes associated with pain processing, emotion regulation, and threat appraisal (Apkarian et al., 2005; Bushnell et al., 2013). In individuals with PTSD, heightened amygdala reactivity, alterations in prefrontal inhibitory control, and changes in insular cortex functioning may contribute to increased sensitivity to internal and external stimuli. As a result, some ordinary bodily sensations may be interpreted as signals of danger or threat (Craig, 2009; Stapleton et al., 2023). These processes may be accompanied by increased autonomic arousal and a persistent state of physiological readiness. Such a state may contribute to the persistence of somatic pain, muscle tension, sleep disturbances, gastrointestinal problems, and other physical symptoms (McEwen, 2007; Wiech, 2016).

Within this context, **interoception** plays a particularly important role. Interoception refers to the processes through which individuals perceive and interpret the physiological state of their bodies, including heart rate, respiration, muscle tension, pain, and other visceral sensations. Research has shown that interoception plays an important role in emotion regulation, decision-making, and the maintenance of bodily homeostasis (Critchley & Harrison, 2013; Khalsa et al., 2018). Conversely, difficulties in interoceptive processing or the misinterpretation of bodily sensations may be associated with increased pain sensitivity, anxiety, and heightened attention to somatic symptoms (Mehling et al., 2012). Therefore, in PTSD, how individuals perceive and assign meaning to bodily sensations may constitute an important link between emotional experience and the persistence of somatic symptoms.

In recent years, **emotional embodiment** has provided a useful conceptual framework for understanding this relationship. From this perspective, emotions are not merely cognitive processes; rather, they are experienced and organized through physiological changes, bodily sensations, and movement patterns (Damasio, 1999; Niedenthal, 2007; Fuchs, 2017). Emotions such as fear, sadness, anger, and shame are accompanied by changes in bodily states, and these changes form an integral part of emotional experience. Accordingly, palpitations, pressure in the chest, stomach pain, muscle contractions, and widespread pain cannot be regarded solely as physical consequences of emotion. Such experiences may also constitute part of the bodily manifestation and experience of emotional processes (Damasio, 1999; Seth & Friston, 2016).

Neuropsychological research has further indicated that awareness of bodily sensations and the ability to regulate responses to them are important components of emotion regulation. Conversely, avoiding bodily sensations or interpreting them as threatening may contribute to persistent physiological arousal and the reinforcement of maladaptive responses (Critchley & Harrison, 2013; Khalsa et al., 2018). In individuals with PTSD, traumatic memories may be represented not only at the cognitive level but also through physiological response patterns and bodily sensations. Consequently, the re-experiencing of bodily states associated with the original trauma may increase the likelihood of activating fear- and trauma-related networks, thereby contributing to the persistence of pain and somatic symptoms (van der Kolk, 2014).

Thus, somatic symptoms and pain in PTSD cannot be explained solely in terms of physical injury or cognitive processes. Rather, these experiences may emerge and persist through ongoing interactions among the brain, body, emotional processes, and nervous system. This conceptualization has important therapeutic implications. In addition to addressing trauma-related cognitions and memories, effective interventions may need to facilitate safe and mindful engagement with bodily sensations, enhance interoceptive awareness, and support the regulation of physiological arousal. This rationale provides a theoretical basis for integrating exposure-based approaches with body-oriented interventions.

Alongside neurobiological and body-oriented approaches, **limit cycle theory**, which originates in dynamical systems theory, may offer a conceptual framework for understanding certain persistent patterns of physiological and neural activity that are potentially relevant to PTSD. The mathematical foundations of limit cycles emerged from the study of nonlinear dynamical systems, including Poincaré's work on nonlinear differential equations. The concept remains a fundamental component of contemporary nonlinear dynamics (Strogatz, 2024). In dynamical systems theory, a

limit cycle is an isolated periodic orbit toward which nearby trajectories may converge under particular conditions. Such a cycle represents a form of sustained oscillatory behavior that can persist without continued external stimulation, provided that the system's underlying dynamics remain stable. Thus, a central characteristic of a stable limit cycle is the capacity of a system to maintain a recurring pattern of activity following an initial perturbation.

Dynamical systems approaches have also been used in computational neuroscience to model patterns of neuronal activity and the dynamics of neural circuits. Izhikevich (2003, 2007) discussed how mathematical models of nonlinear dynamical systems can be used to describe a range of neuronal behaviors and oscillatory activity patterns. Within such models, neural activity is not determined solely by external stimuli; the intrinsic properties and interactions of the system may also contribute to the persistence of particular activity patterns. Under certain conditions, therefore, neural circuits may exhibit sustained activity or oscillatory behavior even after the initial input has diminished. These models provide a theoretical basis for examining how internal system dynamics may contribute to the persistence of physiological and behavioral responses (Izhikevich, 2003, 2007).

Although limit cycle theory was not developed specifically to explain PTSD, it may serve as a conceptual analogy for exploring the persistence of certain neural, emotional, and physiological responses associated with the disorder. Exposure to a traumatic event can strongly activate networks involved in threat processing, fear, pain, and emotion regulation. Under ordinary conditions, these responses would be expected to diminish as the threat subsides. However, in some individuals, particularly those with PTSD, heightened arousal, hypervigilance, muscle tension, and sensitivity to bodily sensations may persist (McEwen, 2007; Borsook et al., 2012). From the perspective of dynamical systems theory, these persistent patterns may be conceptualized as activity patterns maintained by the interacting properties of the system. Their similarity to limit-cycle dynamics is a theoretical proposition, however, rather than an established description of the neurobiology of PTSD.

This conceptual framework is consistent with broader findings from the neuroscience of pain. Borsook et al. (2012) described persistent changes in neural systems associated with pain, emotion, and stress that may contribute to the continuation of chronic pain even in the absence of ongoing tissue damage. Similarly, Loeffler (2023) discussed the relationship between chronic pain and persistent patterns of neural activity, including changes that may limit functional flexibility in neural systems. These findings provide a rationale for investigating whether some somatic symptoms and pain in PTSD are associated with persistent neural and emotional response patterns that emerge following trauma and are maintained by subsequent psychological and physiological processes. However, whether these patterns in PTSD can be adequately modeled using limit-cycle dynamics remains an empirical question.

Within this framework, emotional and bodily avoidance may contribute to the maintenance of persistent response patterns. Individuals with PTSD may avoid traumatic memories, associated emotions, and bodily sensations linked to the traumatic experience. Although avoidance may reduce distress in the short term, it can interfere with trauma processing and limit opportunities to modify maladaptive emotional and physiological responses over time (Foa et al., 2018; van der Kolk, 2014). Consequently, avoidance may contribute to the persistence of heightened arousal and

pain. From the perspective of limit cycle theory, avoidance can therefore be considered a potential maintaining process that may reduce opportunities for adaptive changes in self-sustaining patterns of arousal and bodily experience. This interpretation provides a theoretical rationale for targeting avoidance and bodily experiences within the proposed intervention.

Accordingly, the present study does not employ limit cycle theory as a disorder-specific theory of PTSD or as an independent therapeutic method. Rather, it uses the theory as a conceptual framework for organizing the rationale underlying the intervention. Within this framework, limit-cycle dynamics provide a way of conceptualizing how traumatic experiences may contribute to persistent patterns of activity in systems associated with emotion, pain, and physiological arousal, and how ongoing emotional and bodily avoidance may impede adaptive regulation of these patterns. An intervention that combines exposure to traumatic memories with mindful, nonjudgmental engagement with bodily sensations and the regulation of physiological responses may therefore, in principle, help increase flexibility in emotional and physiological responding and reduce somatic symptoms and pain. The extent to which this theoretical rationale translates into measurable treatment effects requires empirical investigation.

Despite considerable advances in PTSD treatment, many established interventions focus primarily on the cognitive processing of traumatic memories, the reduction of avoidance behaviors, or the modification of dysfunctional beliefs. Exposure-based therapies, cognitive processing therapy, and eye movement desensitization and reprocessing (EMDR) have evidence supporting their effectiveness in reducing PTSD symptoms. Nevertheless, some patients may continue to experience somatic symptoms, chronic pain, or physiological arousal following treatment (van der Kolk, 2014; Foa et al., 2018). A reduction in cognitive and emotional symptoms does not necessarily indicate that all trauma-related bodily and physiological difficulties have resolved. This possibility highlights the need to investigate interventions that address bodily experience more explicitly alongside established PTSD treatment targets.

In recent years, body-oriented approaches have sought to address this gap by emphasizing interoceptive awareness, autonomic regulation, and the processing of bodily experiences (Ogden et al., 2006; Peris & Hoven, 2018). However, some of these approaches place less emphasis on systematic exposure to traumatic memories or do not explicitly adopt a theoretical framework for explaining the persistence of neural and emotional response patterns. Conversely, exposure-based therapies primarily emphasize the processing of traumatic memories and the reduction of cognitive and behavioral avoidance, while bodily sensations and the regulation of physiological responses may not always constitute equally explicit treatment targets (Foa et al., 2018). The purposeful integration of these two approaches may therefore help address the conceptual gap between **trauma processing** and **the regulation of bodily experience**.

On this basis, the present therapeutic model was developed by integrating exposure therapy and emotional embodiment within a **limit-cycle framework**. Exposure therapy remains the central component of the intervention; however, exposure is not restricted to recalling or recounting the traumatic event. Instead, mindful engagement with bodily sensations, the enhancement of interoceptive awareness, and the regulation of physiological responses are systematically incorporated into the therapeutic process. During exposure to trauma-related memories and stimuli, individuals are guided to notice and experience bodily sensations, such as pain, pressure,

muscle tension, palpitations, and other internal sensations, without automatically avoiding, suppressing, or catastrophically interpreting them (Ogden et al., 2006; Levine, 2010; Peris & Hoven, 2018). Within this model, the limit-cycle framework provides a conceptual rationale for guiding the gradual regulation of interactions among somatic, sensory, physiological, autonomic, emotional, behavioral, and cognitive processes. The proposed outcome is a reduction in somatic symptoms and pain.

The principal distinguishing feature of this model is the integration of three complementary components within a unified conceptual framework. First, exposure therapy serves as the primary means of addressing trauma-related fear and reducing avoidance. Second, emotional embodiment provides the rationale for increasing awareness of bodily sensations and integrating bodily experience into the processing and regulation of emotional and physiological responses. Third, limit cycle theory offers a conceptual perspective for considering how persistent activity patterns may emerge and be maintained within systems associated with fear, pain, and emotion (Izhikevich, 2003, 2007; Strogatz, 2024). In this study, the limit cycle is therefore neither a therapeutic technique nor an independent treatment protocol. Rather, it serves as a conceptual framework for explaining the integration of exposure therapy and emotional embodiment and for guiding the selection and sequencing of regulatory techniques. The proposed approach draws on negative-feedback principles as a conceptual rationale for supporting regulation across physiological, somatic, autonomic, emotional, behavioral, and cognitive domains; whether these processes account for treatment-related changes remains to be established empirically.

The rationale for conducting the present study rests on three principal considerations. First, the burden and persistence of somatic symptoms and pain in PTSD suggest that interventions focused exclusively on psychological symptoms may not address every aspect of patients' clinical experiences. Second, findings concerning interoception, emotional embodiment, and persistent patterns of neural activity provide a theoretical basis for proposing that the direct experience and regulation of bodily sensations may help target processes involved in the maintenance of arousal and pain. Third, because exposure-based therapies and body-oriented approaches address different aspects of these processes, integrating them within a unified conceptual framework may allow the evaluation of a more comprehensive intervention. This integration is particularly relevant because the primary outcomes of the present study—symptom severity and somatic pain—are directly related to bodily and physiological experiences.

Within this framework, it is hypothesized that simultaneous exposure to traumatic memories and bodily experiences, accompanied by reduced avoidance, greater engagement with bodily sensations, and the gradual regulation of physiological arousal, may facilitate changes in persistent neural and emotional response patterns. These changes may, in turn, reduce sensitivity to bodily sensations and ultimately contribute to reductions in somatic symptoms and chronic pain. Accordingly, the proposed therapeutic model may address dimensions of PTSD that have received comparatively less explicit attention in some conventional interventions. Nevertheless, the magnitude and durability of these potential effects must be established through empirical evaluation.

Despite evidence supporting exposure therapy and body-oriented interventions as separate approaches, the literature reviewed for the present study did not identify an empirical investigation

specifically examining the effectiveness of **exposure therapy grounded in emotional embodiment within a limit-cycle framework** in reducing somatic symptoms and pain among individuals with PTSD. The principal research gap is therefore not simply a lack of studies on PTSD or chronic pain, but the limited empirical evidence concerning this particular integration of theoretical and therapeutic approaches and its effects on somatic outcomes. An empirical evaluation of the proposed model may help determine whether systematically incorporating bodily experience and physiological regulation into exposure therapy yields additional benefits in reducing the severity of somatic symptoms and pain.

Research Question: Is exposure therapy grounded in emotional embodiment within a limit-cycle framework effective in reducing symptom severity and somatic pain among individuals with post-traumatic stress disorder?

Methodology

Research Design

The present study employed a quasi-experimental pretest–posttest control-group design with a three-month follow-up assessment. Following participant selection, participants were randomly assigned to the experimental and control groups. The dependent variables were assessed in both groups at three time points: pretest, posttest, and three-month follow-up. In addition to routine pharmacological treatment, the experimental group received Embodied Emotion Exposure Therapy (EET), whereas the control group continued to receive pharmacological treatment alone. The purpose of this design was to examine the effects of the intervention and the extent to which its effects were maintained at follow-up.

Study Population

The study population consisted of individuals with post-traumatic stress disorder (PTSD) who attended Sedaye Zendegi Clinic in Tehran during the Iranian calendar year 1404 (2025–2026). Selecting a single treatment center facilitated regular access to eligible patients, implementation of the intervention in a relatively consistent clinical setting, and better coordination of the assessment procedures, pharmacological treatment, and therapy sessions. In addition, conducting the study in a single setting with a consistent referral and diagnostic process allowed for greater control over some implementation-related factors that could influence the course of the study. However, recruiting participants from a single treatment center limited the generalizability of the findings to patients attending other centers, cities, and demographic settings. This limitation was acknowledged in the interpretation of the findings.

Sampling Method and Sample Size

The required sample size was estimated using G*Power software. With statistical power set at 0.87, a significance level of 0.05, and an effect size of 0.60, the estimated sample size was 20 participants per group. During recruitment, 40 patients attending the clinic who met the eligibility criteria were selected and randomly assigned to the experimental and control groups. Of the 40 initial participants, two participants in the experimental group withdrew from the study during the intervention and were subsequently excluded from the final analysis. Consequently, 18 participants remained in the experimental group and 20 in the control group. All 20 participants in the control group completed the study through the end of the intervention period. Participant selection, allocation, follow-up, and attrition are illustrated in Figure 1, which presents the participant flow diagram (CONSORT diagram).

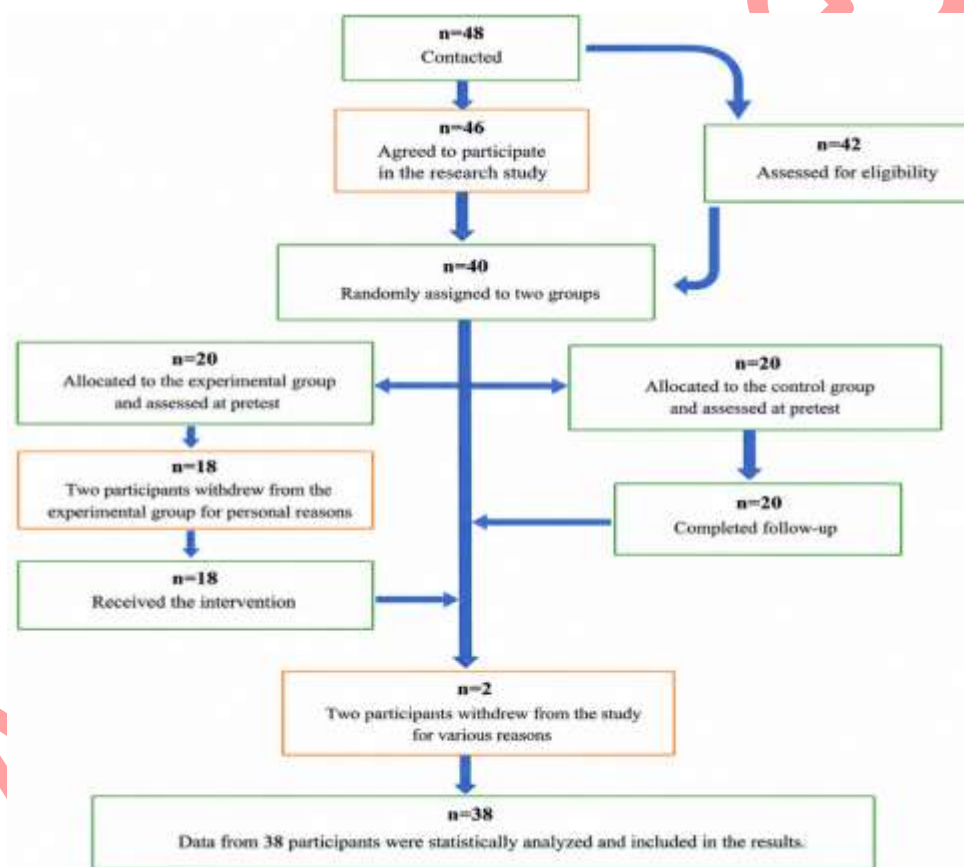


Figure 1. CONSORT Flow Diagram of Study Participants

Inclusion and Exclusion Criteria

The inclusion criteria were: (1) a diagnosis of PTSD established through a clinical interview conducted by the clinic's clinical psychologist and psychiatrist; (2) provision of informed consent to participate in the study; (3) absence of psychotic psychiatric disorders; (4) no use of illicit substances; and (5) absence of other major psychiatric disorders.

Discontinuation of medication prescribed by the clinic's psychiatrist and failure to attend or participate in two therapy sessions were considered exclusion criteria. Participants in the experimental group continued their prescribed pharmacological treatment throughout the intervention. The intervention sessions began one month after the initiation of pharmacological treatment, and the therapeutic protocol was delivered over a two-month period.

Data Collection Instrument

Brief Pain Inventory (BPI)

The Brief Pain Inventory (BPI) was used to assess somatic pain and its associated functional consequences. Developed by Cleeland and Ryan (1991), the BPI is widely used to assess **pain severity** and the extent to which **pain interferes** with various aspects of an individual's life. In addition to measuring pain intensity, the BPI assesses pain interference with daily activities, social functioning, mood, sleep, and quality of life. In the present study, the pain severity subscale was used to assess the intensity of somatic pain, while the pain interference subscale was used to evaluate the impact of pain on participants' daily functioning (Cleeland & Ryan, 1991; Tan et al., 2004).

Regarding its psychometric properties, previous studies have reported satisfactory internal consistency for the BPI, with Cronbach's alpha coefficients of 0.85 for the pain severity subscale and 0.88 for the pain interference subscale (Tan et al., 2004). Furthermore, Keller et al. (2004) reported that the instrument demonstrated appropriate clinical sensitivity in assessing pain severity and pain-related functional impairment.

Regarding construct validity, factor analyses have supported a two-factor structure comprising pain severity and pain interference with functioning (Cleeland & Ryan, 1991; Keller et al., 2004). In addition, the significant associations between BPI scores and measures of quality of life, sleep disturbance, depression, and physical functional limitations provide evidence of its convergent validity (Mendoza et al., 2006).

In Iran, the psychometric properties of the Persian version of the BPI have also been supported. Vakilzadeh and Nakhai (2006) confirmed the construct validity of the Persian version through factor analysis and reported a Kaiser–Meyer–Olkin (KMO) value of 0.87. Similarly, Majidi et al. (2017) reported satisfactory reliability and validity of the Persian version in patients with cancer and chronic pain.

Development and Validation of the Treatment Protocol

The treatment protocol used in the present study was developed using a qualitative approach and the thematic network analysis method proposed by Attride-Stirling (2001). In the first stage, relevant literature and theoretical foundations pertaining to exposure therapy, emotion regulation, neuroscience, and limit cycle theory were reviewed and analyzed. The extracted themes were then organized into basic themes, organizing themes, and global themes, with the overarching theme of the limit cycle serving as the central organizing concept. This process was intended to inform the

development of a preliminary therapeutic model based on theoretically relevant mechanisms of change, recovery, and the regulation of emotional and bodily experiences.

The protocol was structured in a table specifying the sequence of sessions, session duration, pre-session assessment, therapeutic objectives, treatment content, types of homework assignments, techniques used, metaphors, and explanations of the function of each metaphor. This structure was intended to ensure consistency between the scientific foundations of the intervention and the communication of therapeutic concepts to patients. In particular, it was designed to make complex concepts relating to emotion, interoception, bodily experience, experiential avoidance, arousal regulation, and sensory exposure understandable and experientially accessible to participants.

The resulting therapeutic model was developed as part of the researcher's dissertation entitled *Development and Validation of a Novel Emotion-Based Exposure Therapy and Investigation of Its Effectiveness on the Severity of Autonomic Nervous System Effects, Somatic Symptoms and Pain, Somatic Complaints, and PTSD Symptom Severity*. Following its development, the model was designated **Embodied Emotion Exposure Therapy (EEET)**.

Content Validity of the Protocol

To assess the content validity of the treatment protocol, two quantitative indices were used: the content validity ratio (CVR), based on Lawshe's method, and the content validity index (CVI), based on the method described by Waltz and Bausell. The protocol was evaluated by a panel of 10 experts, comprising five psychologists and five psychiatrists. The results indicated a content validity ratio of 0.92 and a content validity index of 0.90. These values indicated a high level of agreement among the experts regarding the necessity, appropriateness, and clarity of the content of the treatment sessions.

Intervention Procedure

The intervention was delivered individually to participants in the experimental group and consisted of 10 sessions. Each session lasted 90 minutes, and the entire protocol was implemented over two months. Treatment was administered by a clinical psychologist licensed by the Iranian Organization of Psychology and Counseling, who had received six months of training from the researcher in implementing the therapeutic protocol.

Participants in the experimental group continued their prescribed pharmacological treatment throughout the intervention, whereas the control group received pharmacological treatment alone.

The content of the sessions was tailored to the history and types of traumatic experiences reported by each participant. However, the overall structure, therapeutic objectives, and underlying rationale of the protocol remained consistent across participants. Accordingly, individual sessions differed in the selection and prioritization of trauma-related experiences and in the examples used to reflect each participant's personal history, rather than in the core principles and components of the intervention.

At the beginning of each session, the effects of the previous session and participants' intervening experiences were assessed. The relevant educational components and exercises were then implemented according to the stage of treatment. The sessions included reviewing homework from the previous session, applying sensory exposure techniques, focusing on trauma-related bodily and emotional experiences, reducing experiential avoidance, and enhancing participants' ability to remain present with bodily sensations and emotional experiences. These activities were conducted in accordance with the objectives of each session. Detailed information regarding the objectives, content, techniques, assignments, and metaphors used in each session is presented in Table 1.

The Function of Metaphors in the Treatment Protocol

Metaphors were not regarded as independent therapeutic techniques or as components separate from exposure therapy. Rather, they were used as educational and communicative tools to facilitate conceptual understanding and prepare participants to engage in therapeutic exercises. Their purpose was to translate abstract and complex concepts relating to emotional experience, emotional embodiment, interoception, experiential avoidance, bodily regulation, and exposure into simpler language and connect them to familiar experiences.

Metaphors served as a bridge between theoretical concepts and participants' personal experiences. First, the relevant concept or mechanism was explained using a metaphor. The therapist then linked the metaphor to the participant's individual experiences, trauma-related symptoms, and somatic pain. Finally, the therapeutic technique associated with that concept was implemented. Accordingly, the functions of metaphors within the protocol included increasing patients' readiness for treatment, establishing a shared therapeutic language, facilitating understanding of the relationship between emotion and the body, helping identify avoidance patterns, and clarifying the rationale for exposure-based techniques.

Session 1

The metaphor "**The Past Is Not Past**" was used to explain how the effects of past traumatic experiences may continue to influence the present. It emphasized that the consequences of some events may remain unresolved and continue to shape an individual's current experiences and everyday life.

Session 2

The Persian proverb "**Once bitten by a snake, one fears even a black-and-white rope**" was used to explain fear generalization and the effects of traumatic experiences on perception, cognition, and behavior. This metaphor helped participants understand that following a traumatic experience, stimuli that would ordinarily be harmless may be perceived as dangerous because of their association with the previous traumatic event.

Session 3

The metaphor **"The Road to the City of Calm Passes Through the City of Turmoil"** was used to explain the process of regulating and recalibrating bodily systems and the role of moving through unpleasant experiences in achieving a more regulated state. The purpose of this metaphor was to simplify the concept of physiological arousal and explain the gradual return of bodily systems toward a regulated state.

Session 4

The metaphor **"To Remember the Beloved, One Must Let Go of the Memory of the Beloved"** was used to explain the distinction between directly experiencing bodily sensations and becoming mentally preoccupied with, or avoiding, those sensations. The metaphor helped participants distinguish between directly experiencing bodily sensations and escaping into self-talk, analysis, or purely mental representations of the traumatic experience.

Session 5

The Persian proverb **"With Patience, Grapes Become Halva"** was used to explain the gradual nature of exposure and the development of greater tolerance for pain and somatic symptoms. The metaphor conveyed the idea that gradually and purposefully remaining with bodily and emotional experiences may change the quality of the experience and increase an individual's capacity to engage with it.

Session 6

Three metaphors were used: **"No Pain, No Gain," "Healing Cannot Occur Without Discomfort,"** and **"Water Must First Be Stirred Up Before It Can Settle Clear."** These metaphors were intended to explain the importance of confronting unpleasant bodily and emotional experiences. They also aimed to reduce expectations of immediate, pain-free relief and increase participants' willingness to experience and observe internal changes without escaping from them.

Session 7

The metaphor **"A Stone Becomes a Ruby Through Patient Endurance"** was used to explain the role of remaining with and tolerating bodily and emotional experiences. It emphasized that traumatic experiences and associated bodily sensations, when approached mindfully rather than avoided, may become more observable and manageable instead of being experienced exclusively as threatening.

Session 8

Three metaphors were used: **"After the Darkest Night Comes the Dawn," "Saying 'Halva' Does Not Make the Mouth Sweet,"** and **"Breaking a Habit Promotes Well-Being."** These metaphors highlighted the distinction between short-term relief obtained through avoidance and the longer-term consequences of avoidance patterns. They helped participants understand the

relationship between behaviors that immediately reduce anxiety, the reinforcement of experiential avoidance, and the potential persistence of distress over time.

Session 9

The metaphor **"Practice Makes Perfect"** was used to emphasize the importance of repetition and continued practice in the therapeutic process and the gradual application of therapeutic skills to more intense experiences. Its purpose was to consolidate the learning acquired in previous sessions and increase participants' proficiency in exposure techniques and their ability to tolerate distress.

Session 10

Two metaphors were used to consolidate treatment: **"Calmness Is Rooted in a Nervous System Tempered by Life's Adversities"** and **"Emotional Regulation and Psychological Calm Require a Resilient Nervous System Capable of Turning Coal into Diamonds Through Life's Challenges."**

These metaphors were intended to summarize the therapeutic process, consolidate the concept of resilience, and facilitate the generalization of acquired skills to everyday life. They helped participants understand that the goal of treatment is neither to eliminate all unpleasant emotions nor to prevent stressful events from occurring, but rather to increase their capacity to confront and regulate emotional and bodily responses to such events.

By emphasizing the gradual development of resilience through confronting difficulties, these metaphors were also intended to strengthen participants' self-efficacy, reduce fear of symptom recurrence, and encourage the independent application of learned skills in future situations.

Overall, metaphors served as mediators between theoretical concepts and clinical experience. They were not treated as independent variables but were used to improve understanding, increase readiness for treatment, and facilitate participants' engagement in exposure and direct experiential work with somatic symptoms and pain.

Overview of the Treatment Sessions

The content of the 10 treatment sessions was organized according to a progressive therapeutic framework. A detailed description of the content of each session is provided in Table 1.

Table 1. Session-by-Session Outline of Emotional Embodiment-Based Exposure Therapy (EET)

Session / Duration / Previous-Session Review	Objective	Content (Method)	Assignment / Task	Techniques	Metaphors	Explanation of Metaphors
Session 1 90 minutes	Become familiar with the participant's life history and biographical background, with particular attention to traumatic experiences.	Establish rapport and empathy; conduct a clinical interview; document the chief complaint; and conduct clinical observation.	Administer the assessment measures: Stressful Life Events Checklist, Brief Pain Inventory (BPI), a PTSD measure, and the Trauma Symptom Checklist-40 (TSC-40).	Explore the participant's insight into the importance of trusting the therapist and the potential need for pharmacological treatment.	"The past is not past."	Which events have not truly ended and continue to unfold in the present?
Session 2 90 minutes	Help the client understand the broad effects of trauma and trauma-related symptoms on mental health.	Explore the role of emotions in cognition and behavior and introduce the bodily effects of emotional experiences.	Identify the effects of emotions on behavior, cognitive biases, and associated bodily responses.	Challenging interview and Socratic dialogue.	"Once bitten by a snake, one fears even a black-and-white rope."	Explain how prior trauma can bias perception, cognition, and behavior, and influence bodily sensations and responses.
Session 3 90 minutes	Provide education about mechanisms of system regulation and their role in automatic regulation.	Introduce emotions and the relationship between emotion dysregulation and autonomic nervous system mechanisms.	Increase awareness of the importance of homeostatic regulation and dysregulation and their interaction with allostasis.	Tailor psychoeducation to the participant's occupation and educational background to explain how the systems function.	"The road to the city of calm passes through the city of turmoil."	Use analogies to illustrate that achieving a desired therapeutic outcome may require an approach opposite to the response that initially seems intuitive.
Session 4 90 minutes	1. Introduce sensory exposure tailored to the type of trauma.	Explain the difference between sensory exposure and verbal/expressive engagement (self-talk).	Identify pain, somatic symptoms, and somatic complaints.	Help the client recognize avoidance of sensory exposure and the tendency to rely on verbal interpretation or narration of the trauma.	"To remember the beloved, one must let go of the memory of the beloved."	A metaphor for avoiding emotional embodiment by replacing direct bodily experience with verbal or mental representations.
Session 5 90 minutes	2. Introduce sensory exposure to trauma, emphasizing resilience in the face of pain, somatic symptoms, and bodily complaints.	Explore trauma-related pain and somatic complaints and identify the client's self-developed strategies for avoiding or escaping them.	Identify mental avoidance and escape in response to flashbacks and trauma reminders, and replace these strategies with spontaneous verbalization.	Explore the history of symptom onset and the temporal relationship between traumatic events, somatic pain and complaints, and associated emotional experiences.	"A certain slap today is better than promised halwa tomorrow."	Help the client anticipate the trade-off between lower-intensity, prolonged pain or symptoms and higher-intensity experiences of shorter duration.
Session 6 90 minutes	Help the client understand the relationship between emotions and interoception.	Explore the relationship between emotions and interoception, practical ways of developing tolerance, and the possibility that somatic symptoms and pain may lessen as trauma-related sensory associations decrease.	Expose the client to interoceptive sensations with the aim of engaging bodily inhibitory receptors and other inhibitory mechanisms involved in symptom modulation.	Experience pain, somatic symptoms, bodily complaints, and related emotions while observing their amplifying effects and practicing tolerance.	"No pain, no gain."	"Therapy cannot be entirely without discomfort." "Muddy water must be stirred before it can settle clear." These sayings emphasize that change may require engaging with initially uncomfortable experiences.
Session 7 90 minutes	Promote the internalization and interoceptive processing of trauma through direct experience of symptoms, pain, and somatic complaints.	Explore trauma through the lens of bodily phenomenological experience, emphasizing emotional activation, preventing escape and experiential avoidance, and fostering resilience.	Align general personal resilience with the capacity to remain engaged with somatic symptoms, pain, and bodily complaints.	Emphasize resilience rather than mere endurance; management, or control of bodily effects. Relate the timing of the traumatic event to the mental representation of trauma through sensory experience of associated emotions.	"Sometimes, being easily means being late"; "With patience, grapes become halva"; "Therapy cannot be entirely without discomfort"; "Muddy water must be stirred before it can settle clear."	Trauma may be experienced as lasting longer on the internal clock than on the external clock, potentially biasing judgments of time and contributing to experiential avoidance.
Session 8 90 minutes	Reduce or eliminate behaviors and mental operations that facilitate experiential avoidance and escape.	Reduce avoidance-related reinforcement that produces immediate relief from anxiety but may be followed by more intense anxiety or distress later.	Identify maladaptive and apparently healthy forms of positive reinforcement that provide immediate relief but may contribute to greater distress in the future.	Discontinue behaviors, mental strategies, and lifestyle patterns used to avoid uncomfortable emotions, including habitual but maladaptive forms of relief.	"After the darkest night comes the dawn"; "Breaking a habit promotes health."	Each process may foster its own opposite. Attempts to force calm may paradoxically produce the opposite effect; every action may be followed by an opposing reaction. This reflects the proposed opponent-process rationale.
Session 9 90 minutes	Repeat the preceding sessions using more severe traumatic experiences.	Repeat the intervention process.	Review assignments from previous sessions.	Reapply the techniques, skills, and therapeutic rationale to subsequent traumatic experiences in the participant's history.	"Practice makes perfect"; "Where there is a will, there is a way."	The client's phenomenological world may change during treatment. In turn, behavior and motivation may become more consistent with emotions and present reality rather than being primarily organized around experiential escape and avoidance.
Session 10 90 minutes	Generalize emotion-regulation skills to work, education, social life, and family relationships.	Apply learned skills to help prevent symptom recurrence.	Facilitate post-traumatic growth in response to everyday stressful or adverse events.	Repeat and adapt the techniques to more severe traumatic experiences.	"Calmness is rooted in a nervous system tempered by life's adversities."	"Emotional regulation and psychological calm require a resilient nervous system capable of turning coal into diamonds through life's challenges."

Abbreviations: EET = Emotional Embodiment-Based Exposure Therapy; BPI = Brief Pain Inventory; PTSD = post-traumatic stress disorder; TSC-40 = Trauma Symptom Checklist-40.

The first session focused on establishing the therapeutic relationship, exploring the participant's life history and traumatic experiences, and conducting an initial assessment.

Sessions 2 and 3 focused on psychoeducation regarding the relationships among emotion, cognition, behavior, and bodily processes, as well as an introduction to the regulation of the nervous and autonomic nervous systems.

In Sessions 4 and 5, sensory exposure to trauma-related experiences and the development of greater tolerance for somatic symptoms and pain constituted the primary focus of the intervention.

Sessions 6 and 7 emphasized the relationship between emotion and interoception, the direct experience of bodily sensations, the reduction of experiential avoidance, and the enhancement of participants' capacity to remain present with their experiences.

Session 8 focused on avoidance patterns and the reinforcing effects of short-term relief.

In Sessions 9 and 10, previously learned processes and techniques were reviewed and practiced, first in relation to more intense experiences and subsequently with the aim of generalizing the acquired skills to different areas of everyday life.

Statistical Analysis

After data collection, the data were entered into SPSS software and analyzed. Given the study design, which included two groups and three measurement time points, a mixed-design repeated-measures analysis of variance (ANOVA) was used to examine changes in pain scores over time and compare patterns of change between the two groups. Time was treated as a within-subjects factor with three levels (pretest, posttest, and follow-up), whereas group was treated as a between-subjects factor with two levels (experimental and control). The analysis examined the main effect of time, the main effect of group, and, in particular, the group-by-time interaction to determine whether changes in pain severity and pain interference differed between the experimental and control groups. The significance level was set at 0.05 for all statistical tests.

Ethical Considerations

The study was conducted after obtaining ethical approval under the code IR.IAU.CTB.REC.1401.138, on 10 Ordibehesht 1404 (April 30, 2025). Before entering the study, all participants provided informed consent, and participation was voluntary. The collected data were used exclusively for research purposes.

Data Analysis

The study included 18 participants in the experimental group (3 men and 15 women) and 20 participants in the control group (3 men and 17 women). The mean age and standard deviation were 39.35 and 9.53 years, respectively, in the experimental group, and 45.34 and 6.56 years, respectively, in the control group.

Regarding marital status, the experimental group included 9 single and 9 married participants, whereas the control group included 13 single and 7 married participants. In terms of educational

attainment, the experimental group comprised 8 participants with a high school diploma, 5 with a bachelor's degree, and 5 with a master's degree or higher. In the control group, 7 participants had a high school diploma, 3 had a bachelor's degree, and 10 had a master's degree or higher.

Table 2 presents the means and standard deviations of the subscales and total score for somatic symptoms and pain in the experimental and control groups at the three assessment points: pretest, posttest, and follow-up.

Table 2. Means and Standard Deviations of Somatic Symptom and Pain Scores at Pretest, Posttest, and Follow-Up

Variable (Subscale)	Group	Pretest, Mean $\pm$ SD	Posttest, Mean $\pm$ SD	Follow-Up, Mean $\pm$ SD
Pain severity	Experimental	22.82 $\pm$ 4.54	12.00 $\pm$ 2.23	10.67 $\pm$ 2.30
	Control	21.25 $\pm$ 4.36	15.15 $\pm$ 2.64	13.90 $\pm$ 2.19
Pain interference	Experimental	47.83 $\pm$ 9.93	21.06 $\pm$ 3.28	22.17 $\pm$ 3.11
	Control	46.90 $\pm$ 10.11	29.10 $\pm$ 3.90	27.90 $\pm$ 4.01
Total score	Experimental	70.67 $\pm$ 11.14	33.06 $\pm$ 5.31	32.82 $\pm$ 4.95
	Control	68.15 $\pm$ 13.38	44.25 $\pm$ 6.84	41.80 $\pm$ 5.59

Note. SD = standard deviation. Values are reported as mean $\pm$ standard deviation.

As shown in Table 2, the mean scores for pain severity, pain interference, and the total somatic symptom and pain score decreased from pretest to posttest in the experimental group, and these reductions were maintained at follow-up. In the control group, decreases in mean scores were also observed at posttest and follow-up; however, the magnitude of change was greater in the experimental group.

The assumptions of normality, homogeneity of variances, and equality of covariance matrices were satisfied. However, the assumption of sphericity was violated; therefore, the degrees of freedom for analyses of within-subject effects were adjusted using the Greenhouse–Geisser correction.

Table 3 presents the results of the multivariate tests examining the effects of emotional embodiment-based exposure therapy (EET) on the subscale scores and total score for somatic symptoms and pain

Table 3. Results of the Multivariate Tests Examining the Effect of the Independent Variable on Somatic Symptoms and Pain

Outcome Measure	Wilks' Lambda	F	df	p	η^2	Observed Power
Pain severity	0.774	5.12	2, 35	0.011	0.226	0.789
Pain interference	0.799	4.41	2, 35	0.020	0.201	0.722
Total score	0.746	5.96	2, 35	0.006	0.254	0.850

Note. $\backslash(F\backslash)$ = F-statistic; $\backslash(df\backslash)$ = degrees of freedom; $\backslash(p\backslash)$ = significance level; $\backslash(\eta^2\backslash)$ = eta-squared effect size. Values have been converted to standard English decimal notation.

As shown in Table 3, emotion embodiment-based exposure therapy had a statistically significant effect on pain intensity, pain interference, and the total somatic symptoms and pain score. Specifically, a significant effect was observed for pain intensity (Wilks' $\Lambda = 0.744$, $\eta^2 = 0.226$, $F = 5.12$, $p = 0.011$), pain interference (Wilks' $\Lambda = 0.799$, $\eta^2 = 0.201$, $F = 4.41$, $p = 0.020$), and the total somatic symptoms and pain score (Wilks' $\Lambda = 0.746$, $\eta^2 = 0.254$, $F = 5.96$, $p = 0.006$).

To evaluate changes in the dependent variables over time and determine whether the patterns of change differed between the two groups, a repeated-measures analysis of variance (ANOVA) was conducted. The results are presented in Table 4.

Table 4. Results of Repeated-Measures Analysis of Variance Examining the Effect of Treatment on Somatic Symptoms and Pain

Variable	Effect	Sum of Squares	Error Sum of Squares	F	p	η^2
Pain intensity	Group effect	72.76	385.57	6.79	0.013	0.159
	Time effect	1804.26	490.52	132.42	0.001	0.786
	Group $\times$ Time interaction	144.04	725.03	7.15	0.001	0.166
Pain interference	Group effect	520.90	1714.25	10.94	0.002	0.233
	Time effect	9450.53	2031.02	167.60	0.001	0.823
	Group $\times$ Time interaction	411.75	2851.10	5.20	0.016	0.126
Total score	Group effect	983.14	2810.55	12.59	0.001	0.260
	Time effect	19513.42	6240.53	127.56	0.001	0.762
	Group $\times$ Time interaction	1025.76	4528.40	8.16	0.001	0.185

Note. F = F-statistic; p = p-value; η^2 = eta-squared effect size

As shown in Table 4, the group $\times$ time interaction was statistically significant for all three outcome variables: pain intensity, pain interference, and the total somatic symptoms and pain score. Specifically, significant group $\times$ time interaction effects were observed for pain intensity ($F = 7.15$, $p = .001$, $\eta^2 = .166$), pain interference ($F = 5.20$, $p = .016$, $\eta^2 = .126$), and the total somatic symptoms and pain score ($F = 8.16$, $p = .001$, $\eta^2 = .185$).

The significant group $\times$ time interaction effects indicate that changes in the outcome measures across the three assessment time points differed between the experimental and control groups. The greater reductions in mean scores observed in the experimental group suggest that participants who received **Embodied Emotion Exposure Therapy (EET)** experienced a different pattern of change over time compared with those in the control group.

To determine which assessment time points differed significantly, post hoc pairwise comparisons were performed using the Bonferroni correction. The results are presented in Table 5.

Table 5. Results of Bonferroni Post Hoc Tests for Somatic Symptoms and Pain

Panel A. Pairwise Comparisons Across Assessment Time Points				
Dependent Variable	Time-Point Comparison	Mean Difference	Standard Error	<i>p</i>
Pain intensity	Pre-test vs. Post-test	8.47	0.75	.001
	Pre-test vs. Follow-up	9.76	0.85	.001
	Post-test vs. Follow-up	1.29	0.57	.085
Pain interference	Pre-test vs. Post-test	22.29	1.54	.001
	Pre-test vs. Follow-up	22.33	1.73	.001
	Post-test vs. Follow-up	−0.04	0.90	1.000
Total somatic symptoms and pain score	Pre-test vs. Post-test	30.76	1.97	.001
	Pre-test vs. Follow-up	32.09	2.14	.001
	Post-test vs. Follow-up	1.34	1.23	.855
Panel B. Between-Group Comparisons				
Outcome Variable	Group Comparison	Mean Difference	Standard Error	<i>p</i>
Pain intensity	Experimental vs. Control	−1.60	0.61	.013
Pain interference	Experimental vs. Control	−4.28	1.29	.002
Total somatic symptoms and pain score	Experimental vs. Control	−5.88	1.66	.001

Note. *p* values in Panel A are Bonferroni-adjusted. Pre-test, post-test, and follow-up refer to the three assessment time points.

Bonferroni-adjusted pairwise comparisons of the marginal means across the three assessment time points, averaged across the experimental and control groups, revealed statistically significant differences between pre-test and post-test scores for pain intensity, pain interference, and the total somatic symptoms and pain score ($p = .001$ for all comparisons). Similarly, significant differences were observed between pre-test and three-month follow-up scores for all three outcome measures ($p = .001$ for all comparisons). In contrast, the differences between post-test and three-month follow-up scores were not statistically significant for pain intensity ($p = .085$), pain interference ($p = 1.000$), or the total somatic symptoms and pain score ($p = .855$). These findings indicate that, when the two groups were considered together, scores decreased significantly from pre-test to post-test and from pre-test to the three-month follow-up, with no statistically significant differences between post-test and follow-up scores.

Between-group comparisons of the marginal means, averaged across the three assessment time points, also revealed statistically significant differences between the experimental and control groups in pain intensity ($p = .013$), pain interference ($p = .002$), and the total somatic symptoms and pain score ($p = .001$). The negative mean differences for the experimental-versus-control comparisons indicate that, on average across the assessment period, the experimental group had lower scores than the control group on all three outcome measures.

Importantly, the repeated-measures analysis of variance revealed statistically significant group $\times$ time interaction effects for pain intensity ($F = 7.15, p = .001, \eta^2 = .166$), pain interference ($F = 5.20, p = .016, \eta^2 = .126$), and the total somatic symptoms and pain score ($F = 8.16, p = .001, \eta^2 = .185$). These significant interactions indicate that the patterns of change across the three assessment time points differed between the experimental and control groups. As illustrated in Figure 4-2, the experimental group showed more pronounced reductions in all three outcome measures from pre-test to post-test, with the lower scores maintained at the three-month follow-up. In contrast, the control group exhibited smaller reductions over the same period.

Taken together, the significant group $\times$ time interactions, the overall between-group differences, and the trajectories depicted in Figure 4-2 support the conclusion that changes in pain intensity, pain interference, and the total somatic symptoms and pain score differed between the experimental and control groups over the assessment period. The absence of statistically significant differences between post-test and three-month follow-up scores is consistent with the maintenance of the observed improvements over the follow-up period. These findings support the potential effectiveness of emotion embodiment-based exposure therapy (EEET) in improving pain-related outcomes among individuals with post-traumatic stress disorder (PTSD), with the observed changes persisting through the three-month follow-up.

Discussion and Conclusion

The present study aimed to investigate the effectiveness of embodied emotional exposure therapy (EEET), guided by the Limited Cycle Theory, in addressing somatic symptoms and pain among individuals with post-traumatic stress disorder (PTSD). The findings indicated statistically significant effects on pain intensity, pain interference, and the total somatic symptoms and pain

score. Furthermore, significant group $\times$ time interaction effects were observed for all three outcome variables, indicating that the patterns of change across the three assessment time points differed between the experimental and control groups. Bonferroni-adjusted pairwise comparisons of the marginal means, averaged across the two groups, revealed significant differences between pre-test and post-test scores and between pre-test and three-month follow-up scores for all three outcomes. However, the differences between post-test and follow-up scores were not statistically significant. In addition, between-group comparisons of the marginal means, averaged across the three assessment time points, revealed significant overall differences between the experimental and control groups. The experimental group showed more pronounced reductions in all three outcome measures than the control group, with lower mean scores at post-test and three-month follow-up. Taken together, the significant group $\times$ time interactions and the trajectories shown in the figure indicate that changes in pain-related outcomes differed between the two groups. Thus, the principal contribution of the present study is that the intervention was associated with changes not only in pain intensity but also in the degree to which pain interfered with daily functioning. From the authors' perspective, these findings may be understood in relation to the interactions among traumatic experiences, emotions, bodily sensations, physiological arousal, and avoidance that may contribute to the persistence of symptoms.

In individuals with PTSD, traumatic experiences may be associated with heightened sensitivity to internal and external stimuli. Under these circumstances, bodily sensations such as pain, muscle tension, pressure, or changes in breathing may rapidly be interpreted as signs of danger. When a bodily sensation is appraised as threatening, emotional and physiological responses may be activated, resulting in increased arousal. Heightened arousal, in turn, may intensify the perception of bodily sensations, prompting the individual to engage in avoidance behaviors or attempt to eliminate the experience immediately. Consequently, a reciprocal cycle may develop among bodily sensations, threat appraisal, arousal, and avoidance. From the authors' perspective, one possible explanation for the changes observed in the present study is that the intervention targeted several components of this potentially symptom-maintaining cycle rather than focusing exclusively on pain itself.

A central component of the intervention was sensory exposure to trauma-related experiences. In this approach, participants were encouraged to experience and observe bodily sensations within a therapeutic context rather than immediately resorting to avoidance, suppression, or distraction when pain or other physical sensations emerged. This process may provide individuals with opportunities to experience unpleasant bodily sensations without automatically engaging in habitual defensive responses. Consequently, sensations previously associated with danger may gradually be experienced under different conditions. Repeated engagement with these experiences may weaken the association between bodily sensations and perceived threat. In turn, secondary emotional and physiological reactions to bodily sensations may become less intense, potentially contributing to changes in perceived pain intensity. Nevertheless, because threat appraisal and physiological arousal were not directly measured in the present study, this explanation should be regarded as a theoretical interpretation rather than a confirmed mechanism of change.

The concept of emotion embodiment is particularly relevant to this process. In the present protocol, bodily sensations were not conceptualized as separate from emotional experiences; rather, they were treated as integral components of individuals' emotional experiences. Accordingly,

participants were encouraged to attend to the relationships among pain, other bodily sensations, emotions, and traumatic experiences instead of regarding physical sensations as independent and inherently threatening phenomena. This approach may have helped participants distinguish between the presence of a sensation and the perceived necessity of responding defensively to it. In other words, the therapeutic objective was not the immediate elimination of bodily sensations but a change in the way individuals related to and responded to those sensations. This conceptualization is consistent with theoretical accounts of embodied emotion and the role of bodily experience in the organization of emotional processes (Damasio, 1999; Niedenthal, 2007; Fuchs, 2017).

Changes in individuals' relationships with their bodily experiences may provide one possible explanation for the observed changes in pain intensity. When individuals feel less compelled to eliminate bodily sensations immediately and can experience them without catastrophic interpretations, secondary increases in anxiety and physiological arousal may also be reduced. Under such circumstances, pain may become less likely to trigger immediate defensive responses and may instead become an experience that can be observed and tolerated within the therapeutic context. Such a shift could weaken the reinforcing relationship between pain and anxiety and potentially contribute to a reduction in pain intensity. Although the present findings are consistent with this interpretation, further research is needed to determine whether these processes mediate the effects of EEET.

The observed changes in pain interference may also be interpreted within this framework. Changes in pain intensity do not necessarily entail equivalent changes in the extent to which pain disrupts everyday functioning. The significant findings for pain interference suggest that the functional consequences of pain also differed across groups and assessment periods. One possible explanation is that an increased capacity to remain in contact with bodily experiences without escaping from or avoiding them may reduce the extent to which pain governs daily behavior and activities. From this perspective, the potential benefits of the intervention may extend beyond changes in the subjective experience of pain to changes in the relationship between pain and everyday functioning. However, because behavioral avoidance and activity engagement were not directly assessed as mechanisms, this explanation remains tentative.

Experiential avoidance provides another theoretical framework for understanding the proposed therapeutic process. Although avoidance may reduce distress in the short term, persistent reliance on avoidance may increase sensitivity to internal experiences and limit opportunities to learn that these experiences can be tolerated without defensive action. Within the present protocol, participants were encouraged to remain in contact with unpleasant experiences rather than continually attempting to suppress or eliminate them. An anticipated consequence of this approach was a reduction in reliance on avoidance as a means of controlling internal experiences. Reduced experiential avoidance could, in principle, enable individuals to respond differently to bodily sensations and thereby contribute to changes in pain-related outcomes. Nevertheless, experiential avoidance was not directly measured in the present study, and its potential role in the observed changes requires empirical investigation.

The Limited Cycle Theory was employed as a conceptual framework for explaining how interacting processes may contribute to the persistence of symptoms. Its use does not imply that a

specific limited cycle has been conclusively established as the mechanism underlying PTSD. Rather, the framework provides a way of understanding how a relatively stable pattern of arousal may persist when positive feedback processes predominate over negative feedback processes. From this perspective, trauma memories, emotions, bodily sensations, physiological arousal, and avoidance may repeatedly activate and reinforce one another, allowing a symptom-maintaining pattern to continue even after the original threat has passed. Changing such a pattern may therefore require more than suppressing a single component; it may require altering the reciprocal relationships among its components.

Consistent with this framework, the present intervention sought to interrupt potentially symptom-maintaining feedback processes by increasing engagement with bodily and emotional experiences and reducing reliance on avoidance. Rather than allowing the emergence of pain to trigger automatic avoidance and immediate relief from distress, participants were encouraged to remain in contact with their experiences within the therapeutic process. This change may have allowed bodily sensations to be experienced without the same degree of reinforcement through avoidant responses. Accordingly, the process can be conceptualized as a shift from a potentially symptom-maintaining cycle toward a different pattern of responding.

The proposed symptom-maintaining cycle can be represented as follows:

Trauma-related stimulus or reminder → bodily sensation → threat appraisal → increased arousal → avoidance → immediate relief from distress → reinforcement of the avoidance pattern → reactivation of the cycle.

The therapeutic pathway proposed in the present study can be represented as follows:

Trauma-related stimulus or reminder → bodily sensation → observation and experience without avoidance → emotional and bodily processing → potentially reduced threat appraisal → potentially reduced arousal → changes in bodily sensitivity and responses → changes in symptoms and pain-related outcomes.

These sequences represent the theoretical rationale underlying the intervention rather than processes directly demonstrated by the statistical analyses. The present study assessed pain-related outcomes and their changes over time but did not directly test every link in either sequence. Accordingly, this proposed model should be regarded as a conceptual framework that warrants further empirical investigation.

Within this model, exposure and emotion embodiment serve distinct but complementary functions. Exposure facilitates direct engagement with trauma-related material, whereas emotion embodiment places the bodily dimensions of emotional experience within the therapeutic process. Consequently, therapeutic work may extend beyond verbal recollection or discussion to include bodily sensations, emotional responses, and physiological experiences associated with trauma. From the authors' perspective, this integration provides a plausible theoretical explanation for why an intervention addressing trauma-related emotional and bodily experiences may be associated with changes in pain outcomes. If a symptom-maintaining pattern involves several interacting dimensions, addressing these dimensions together may be relevant to understanding changes in

both pain intensity and pain interference. However, the present study does not establish whether the combination of exposure and emotion embodiment is more effective than either component alone.

The metaphors incorporated into the protocol may also have served a facilitating function. They were not intended as independent therapeutic agents but were used to communicate complex therapeutic concepts in accessible language and help participants understand the rationale for exposure. Through metaphors, concepts such as the potential long-term consequences of avoiding internal experiences, the difference between directly experiencing a bodily sensation and merely talking about it, and the time and repetition required to modify an established response pattern may have become more understandable. Metaphors may therefore have increased participants' understanding of the therapeutic process and clarified the purpose of exposure. They may also have helped reduce uncertainty or resistance and supported engagement with therapeutic exercises. However, because the independent contribution of metaphors was not assessed, their specific role in the outcomes of the present study remains undetermined.

An important consideration is that exposure to bodily sensations does not necessarily involve deliberately intensifying pain or increasing participants' suffering. The objective is to facilitate the experience and observation of sensations within appropriate limits, allowing participants to remain in contact with the experience and engage with it without relying on avoidance. Accordingly, adjusting the intensity of exposure to participants' individual circumstances and capacities is important. From this perspective, the therapeutic value of exposure lies in changing the way individuals respond to and interpret their experiences rather than deliberately producing or intensifying symptoms.

The maintenance of changes at the three-month follow-up may also be considered within this theoretical framework. The Bonferroni-adjusted comparisons showed that, when the experimental and control groups were considered together, the differences between pre-test and follow-up scores were statistically significant for all three outcomes, whereas the differences between post-test and follow-up scores were not statistically significant. This pattern indicates that the overall time-related changes observed across the two groups were maintained from post-test to follow-up. Results show descriptively that the experimental group's mean scores remained below its post-test baseline levels at the three-month follow-up, while the control group showed comparatively smaller reductions. The significant group $\times$ time interactions provide additional evidence that the trajectories of change differed between the groups. However, because the Bonferroni time-point comparisons were averaged across groups, they do not independently establish the statistical significance of the post-test-to-follow-up change within the experimental group. One possible explanation is that learning acquired during treatment, including the capacity to experience bodily sensations without immediately engaging in avoidance, may have generalized beyond the therapeutic setting. From this perspective, the relevant change may involve the development of a different way of responding to symptoms rather than their immediate and complete elimination. If such changes in responding persist after treatment, improvements in pain-related outcomes may also be maintained. Nevertheless, because the relevant learning processes and potential mediating variables were not directly assessed, this interpretation remains hypothetical. Furthermore, the absence of a statistically significant difference between post-test and follow-up does not, by itself, establish equivalence between the two assessments.

A potential strength of the intervention is its consideration of pain within its emotional and trauma-related context. Within this framework, pain is not treated as an isolated phenomenon but is understood in relation to a broader network of experiences involving trauma, emotion, bodily sensations, attention, arousal, and avoidance. This perspective suggests that changes in pain-related outcomes may be associated with changes in how these interconnected experiences are approached and responded to. The findings of the present study are consistent with the possibility that an intervention addressing trauma-related bodily and emotional experiences may be associated with changes in both pain intensity and the functional interference associated with pain. Further studies are needed to determine which aspects of the intervention contribute most strongly to these outcomes.

From a methodological perspective, a distinction must be maintained between observed treatment outcomes and the mechanisms that may underlie them. The present study identified significant effects and group $\times$ time interactions for pain intensity, pain interference, and the total somatic symptoms and pain score. However, potential mechanisms, including reductions in experiential avoidance, changes in interoceptive awareness, altered threat appraisal, and physiological regulation, were not directly assessed. Therefore, the findings do not establish that the observed changes occurred through any one of these pathways. Rather, the proposed mechanisms are theoretically plausible explanations that are consistent with the intervention's rationale and warrant direct examination in future research.

Several limitations should be considered when interpreting the findings. First, the sample was recruited from a single treatment center, which may limit the generalizability of the results to other clinical settings, geographical areas, and demographic populations. Second, the sample size was limited, and two participants in the experimental group withdrew during the study. Third, the use of self-report measures to assess pain may have introduced response bias. Fourth, although participants in both groups received pharmacological treatment, the effects of potential changes in medication were not independently controlled for in the analyses. The absence of an active control group also limits the extent to which the effects of EEET can be distinguished from those of other psychological interventions. Finally, the proposed mechanisms were not directly tested, and the contribution of individual intervention components, including the metaphors used in the protocol, could not be established.

In light of these limitations, future research should replicate the intervention across multiple centers and with larger samples. Researchers should also assess potential process variables, including experiential avoidance, interoceptive awareness, emotion regulation, and threat appraisal, at multiple stages of treatment. Such assessments could help determine whether changes in these variables precede or accompany changes in pain-related outcomes and whether they statistically mediate the relationship between treatment and outcomes. Physiological measures may further clarify whether changes in clinical outcomes are accompanied by changes in physiological arousal. The use of an active control group would also strengthen the evaluation of the specific contribution of EEET relative to other psychological interventions. Further investigations could also examine the contribution of individual therapeutic components, including sensory exposure, emotion embodiment, and the metaphors incorporated into the protocol.

Conclusion

The findings of the present study indicate that embodied emotional exposure therapy (EEET), guided by the Limited Cycle Theory, was associated with significant changes in pain intensity, pain interference, and the total somatic symptoms and pain score among individuals with PTSD. Significant group $\times$ time interactions indicated that the patterns of change in these outcomes differed between the experimental and control groups across the pre-test, post-test, and three-month follow-up assessments. Bonferroni-adjusted pairwise comparisons of the marginal means, averaged across the two groups, revealed significant differences between pre-test and post-test scores and between pre-test and three-month follow-up scores for all three outcomes. In contrast, differences between post-test and follow-up scores were not statistically significant. Between-group comparisons of the marginal means, averaged across the three assessment time points, also revealed significant overall differences between the experimental and control groups. The experimental group exhibited more pronounced reductions in pain intensity, pain interference, and the total somatic symptoms and pain score than the control group, and these lower mean scores remained evident at the three-month follow-up. The significant group $\times$ time interactions support the interpretation that the two groups followed different trajectories of change over the assessment period. However, the Bonferroni time-point comparisons were averaged across groups and therefore should not be interpreted as direct tests of within-group changes in the experimental group alone. Taken together, the statistical findings are consistent with the potential effectiveness of EEET in improving pain-related outcomes, with the observed between-group differences and differential trajectories extending through the three-month follow-up period.

The authors propose that the observed changes may be understood in relation to the intervention's emphasis on the interplay between trauma-related experiences, emotions, and bodily sensations. Sensory exposure may have facilitated direct engagement with bodily and emotional experiences, while the emotion embodiment framework placed the relationship between emotional and bodily processes at the center of treatment. The Limited Cycle Theory provided a conceptual basis for understanding how changes in responses to these experiences might influence a potentially self-sustaining pattern of symptoms. However, because the proposed mechanisms were not directly measured, their contribution to the observed outcomes remains to be established. Future research should investigate these processes directly and further evaluate the effectiveness and durability of EEET in larger and more diverse clinical samples.

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