Psychiatry Research 270 (2018) 1105–1109

Contents lists available at ScienceDirect

Psychiatry Research

journal homepage: www.elsevier.com/locate/psychres

Tonic immobility during re-experiencing the traumatic event in posttraumatic stress disorder

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ARTICLE INFO

Keywords:
Defence responses
Tonic immobility
Posttraumatic stress disorder
Peritraumatic reactions
Re-experiencing
Mediation

ABSTRACT

Tonic Immobility (TI) is an evolved defence response, characterized by physical immobility. Peritraumatic TI has been linked to posttraumatic stress disorder (PTSD). However, samples sizes in clinical studies have been small, and little is known about TI reactions *post* trauma, for instance during trauma reminders. The prevalence of peritraumatic TI and TI during re-experiencing the traumatic event was examined by self-report in 184 patients with chronic PTSD. Moderate peritraumatic TI was reported by 26.6% of the participants (n = 49) and extreme peritraumatic TI by 52.2% (n = 96). During re-experiencing the traumatic event, 35.3% (n = 65) reported moderate TI, and 37.0% (n = 68) extreme TI. Peritraumatic TI was related to PTSD symptom severity and TI during re-experiencing mediated this relationship. In line with previous findings, reports of peritraumatic TI were high among PTSD patients. In addition, we showed that it often re-occurred during re-experiencing the traumatic event. The prevalence of TI at different stages post trauma warrants future study.

1. Introduction

Tonic immobility (TI) is an adaptive, reflexive and involuntary defence response, characterised by profound but reversible motor inhibition and muscular rigidity, supressed vocalization, tremors, intermittent periods of eye closure, and analgesia with evidence of a preserved awareness of the surroundings (Gallup, 1977; Marx et al., 2008). TI has been observed across species and is thought to occur in life-threatening situations, which are both inescapable and illicit intensive fear. It is believed to be a late defence response when other responses, freezing, flight and fight responses, are exhausted (Bracha, 2004; Hagenaars et al., 2014; Marks, 1987; Volchan et al., 2017). Although often used interchangeably, freezing and TI refer to different responses in the defence cascade (Hagenaars, 2016; Kozlowska et al., 2015; Schauer and Elbert, 2010). Freezing is an early response to danger, aimed at optimally assessing threat and preparing the organism for action (i.e. flight or fight). TI is thought to occur when threat is extremely close, and flight or fight is no option.

Several studies have shown that TI has been preserved in human beings. For instance, 21 to 70% of the survivors of sexual assault reportedly experienced TI during the assault (Bovin et al., 2008; Galliano et al., 1993; Hagenaars, 2016; Heidt et al., 2005; Moller et al., 2017). TI can also be elicited during non-sexual traumatic events, such as violent robbery or air disaster (Abrams et al., 2009; Rocha-Rego et al., 2009), although there is data suggesting that the highest TI rates are observed for sexual trauma (during child- or adulthood; Hagenaars, 2016; Kalaf et al., 2015, 2017). In clinical samples, prevalence rates of peritraumatic TI are generally high (43–73%; Fiszman et al., 2008; Heidt et al., 2005). Moreover, the experience of TI during a traumatic experience has been positively linked to symptoms of posttraumatic stress disorder (PTSD) in cross-sectional studies (Bovin et al., 2008; Hagenaars, 2016; Heidt et al., 2005; Humphreys et al., 2010; Kalaf et al., 2015; Portugal et al., 2012; Rocha-Rego et al., 2009). Most recently, a prospective study demonstrated that peritraumatic TI during sexual assault increases the risk for subsequent PTSD development (Moller et al., 2017). In line, induced non-movement or higher self-reported TI during analogue trauma (i.e., a trauma film) was associated with more subsequent intrusive memories of trauma (Hagenaars et al., 2010; Hagenaars et al., 2008). It has even been shown that those who experienced peritraumatic TI and subsequently developed PTSD responded worse to treatment with medications (SSRI's or SNRI's) compared to those without peritraumatic immobility reactions (Fiszman et al., 2008; Lima et al., 2010).

In non-human animals, TI occurs under conditions of restraint

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https://doi.org/10.1016/j.psychres.2018.06.051
Received 14 November 2017; Received in revised form 11 April 2018; Accepted 20 June 2018
Available online 21 June 2018

(inescapability) and extreme fear. Restraint in humans might also be subjective, though. That is, TI might occur under conditions of perceived inescapability (Marx et al., 2008). Indeed, experimental paradigms that prompted perceived inescapability and stress elicited TI reactions as well (Hagenaars and Putman, 2011; Mooren and van Minnen, 2014). Moreover, TI might also be provoked in situations that remind of the trauma, because these situations are perceived as inescapable stressors (Ehlers and Clark, 2000), and because trauma reminders trigger responses that were shown during the actual trauma (Foa and Kozak, 1986; Lang, 1968). Few studies explored the occurrence of TI during trauma reminders. Volchan et al. (2011) presented trauma-exposed participants with an autobiographical trauma script and found that script presentation evoked TI reactions. Moreover, this experimentally induced TI was positively related to reports of peritraumatic TI. In similar fashion, Alves et al. (2014) showed that higher levels of TI during violent crime were associated with increased heart rate in response to trauma-relevant pictures (i.e. pictures of a gun), while those with lower TI during violent crime responded with reduced heart rate. Together, these findings raise the question whether TI reactions might also occur in daily life in reaction to trauma-reminders, and specifically, whether PTSD patients might experience TI during re-experiencing the traumatic event (e.g. during unwanted thoughts or flashbacks). By the best of our knowledge, no one has yet investigated whether PTSD patients experience TI during re-experiencing the traumatic incident. This might be of particular relevance, as immobility might contribute to feelings of uncontrollability and negative appraisal, which are important factors in the maintenance of PTSD (Ehlers and Clark, 2000; Foa et al., 1992).

The aim of the current study is to investigate TI reactions in a large sample of PTSD patients. Up until now, most studies examined TI in large undergraduate or community samples (Abrams et al., 2009, 2012; Bovin et al., 2008; Hagenaars, 2016; Humphreys et al., 2010; Kalaf et al., 2015, 2017), while samples in clinical studies were relatively small ($N < 50$; Fiszman et al., 2008; Lima et al., 2010; Rocha-Rego et al., 2009; Volchan et al., 2011). More specifically, we aim to examine the prevalence and severity of peritraumatic TI and TI during re-experiencing. Second, we will test whether peritraumatic TI is associated with PTSD symptom severity, and third, whether TI during re-experiencing mediates this relationship.

2. Methods

2.1. Participants

Three hundred eighty-one patients were recruited from a large Mental Health Care organization in The Netherlands between January 2013 and August 2015. All were referred for treatment of their posttraumatic stress disorder (PTSD). Participants were evaluated by experienced clinicians using a structured interview (MINI) to establish DSM-IV defined PTSD diagnosis. All participants completed assessments as part of routine outcome monitoring before starting the treatment. Two hundred and seven participants agreed to participate in the current study and completed two additional questionnaires after providing informed consent. Routine outcome data of PTSD symptom severity was missing for eight participants; nine participants did not complete the PTSD and TIS-TI measures within one week; and six participants scored below clinical cut-off on the PTSD symptom severity measure (i.e. PSS-SR score < 15). These 23 participants were excluded from further analyses. This resulted in a sample size of 184 participants, of which 128 female (69.6%) and with a mean age of 39.4 years (SD = 10.5).

2.2. Measurements

2.2.1. PTSD symptoms

PTSD symptom severity was assessed with the Posttraumatic Stress Symptom Scale, Self Report (PSS-SR; Foa et al., 1993), a 17-item questionnaire with which patients rate the frequency and severity of DSM-IV PTSD symptoms (score range 0–51, with higher scores indicating worse symptoms). Analyses showed a high internal consistency ($\alpha = 0.91$; Foa et al., 1993). The Dutch version also shows good internal consistency (current study $\alpha = 0.84$; Mol et al., 2005).

2.2.2. Tonic immobility

Tonic immobility was assessed using the Dutch translation of the Tonic Immobility Scale (TIS; Fuse et al., 2007), a self-report measure that consists of 10 items that are scored on a 7-point Likert scale, ranging from 0 (not at all) to 6 (extremely/very much). The TIS was originally developed to assess TI during sexual abuse. To assess TI during different trauma's (TIS–TI_{trauma}), we adjusted the words “sexual abuse” to “most impactful traumatic event” (see also Lima et al., 2010; Hagenaars, 2016, Bados et al., 2008) and to assess TI during re-experiencing (TIS-$TI_{re\text{-}exp}$) we adjusted the text to “the most severe re-experiencing of the traumatic event” . Exploratory and confirmatory factor analyses showed that the original TIS comprises two subscales (Fuse et al., 2007), namely TIS–TI (7 items; range 0–42) and TIS-fear (3 items; range 0–18). Reliability of the original TIS–TI for sexual abuse was $\alpha = 0.86$ (Fuse et al., 2007), and $\alpha = 0.78$ for the translated version for all trauma types (Hagenaars, 2016). The reliability for the TIS–TI_{trauma} and TIS–$TI_{re\text{-}exp}$ was adequate in the current sample ($\alpha = 0.71$ and 0.72, respectively). The TIS-fear subscale is less consistent in psychometric properties. While the original TIS-fear for sexual trauma was moderately reliable (Fuse et al., 2007) translated versions for all trauma types have shown weaker reliability ($\alpha = 0.45$ Hagenaars, 2016; $\alpha = 0.43$ Bados et al., 2008; $\alpha = 0.52$ current sample). Moreover, the TIS-fear is theoretically less consistent as it encompasses both fear and dissociation items (Hagenaars, 2016; Rocha-Rego et al., 2009). Consequently, in many studies only the immobility items were used to assess TI (e.g. Fiszman et al., 2008; Hagenaars and Putman, 2011; Lima et al., 2010; Rocha-Rego et al., 2009). In line, we used the TIS–TI only. For the purpose of determining TI prevalence during trauma and re-experiencing and comparing peritraumatic TI prevalence across studies, TIS-TI_{trauma} and TIS–$TI_{re\text{-}exp}$ scores were categorized in three clusters: low (TIS–TI score 0–20), moderate (TIS–TI score 21–27), and extreme (TIS–TI score ≥ 28) (Fuse et al., 2007; Hagenaars, 2016; Heidt et al., 2005).

2.3. Procedure

Participants completed the PSS-SR questionnaire before the start of treatment as part of routine outcome monitoring. After signing informed consent, they then completed both TIS-TI measures. All measures were completed via a secured web-based platform. The study was approved by the Ethics Committee Faculty of Social Sciences (ECSS) of the Radboud University, Nijmegen, The Netherlands.

2.4. Analysis

Prevalence and severity of peritraumatic TI and TI during re-experiencing (aim 1) are presented with percentages. To examine the relationship between peritraumatic TI and PTSD and the possible mediating role of TI during re-experiencing (aim 2 and 3), we first calculated Pearson's r correlations. Next, a single mediation analysis was conducted using the PROCESS Macro for SPSS (model 4; Hayes, 2013) to investigate the hypothesis that TI during re-experiencing mediated the effect of peritraumatic TI on PTSD symptom severity. The PROCESS Macro utilizes a regression framework with bootstrapping to examine the indirect effect of a predictor (X) on an outcome (Y) through a proposed mediator (M). Indirect effects are calculated as the product of the beta-coefficients of two linear models ($a \times b$). The first model predicts the mediator (M) from the proposed independent variable (X; path a). The second model predicts the proposed outcome (Y) variable form the proposed mediator (M; path b, see

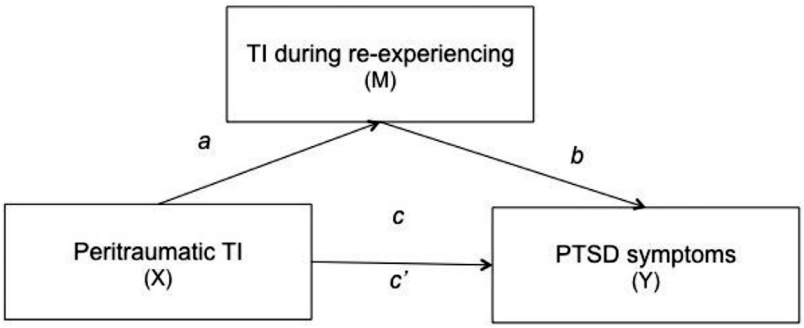

Fig. 1. Proposed model: TI during re-experiencing as a potential mediator for the effect of peritraumatic TI on posttraumatic stress symptom severity. *Notes.* a = effect of X on M; b = effect M on Y; c = total effect of X and Y; c' = direct effect of X on Y controlling for M.

Fig. 1). Within the PROCESS Macro bootstrapping is used in order to construct bias-corrected 95% confidence intervals (CIs) and infer the significance of the indirect effect. Bootstrapping is a method that makes no assumptions about the sampling distribution of the indirect effect. In the current study, we used 10.000 bootstrapped samples. An indirect effect is assumed to be significant if the CIs around the product of path a and b do not include zero (Preacher and Hayes, 2008).

All variables were standardized to yield completely standardized indirect effects. Given that the mediation analysis was conducted among cross-sectional data, we performed a specificity analysis to test the directionality of the observed effects (Preacher and Hayes, 2004; Garey et al., 2016). In this model we reversed the predictor (i.e. TIS–TI_{trauma}) and mediator (i.e. TIS–$TI_{re\text{-}exp}$) variables. To explore potential moderators of our mediation model, we conducted a conditional process analysis using model 58 of the PROCESS Macro.

3. Results

Most participants reported sexual abuse (n = 81; 44.0%) or physical violence (n = 56; 30.4%) as their most impactful traumatic incident. Details about trauma exposure can be found in Table 1. For 141 participants (76.6%), the traumatic incident happened more than five years ago, for 17 participants (9.2%) three to five years ago, for 22 participants (12.0%) six months to three years ago, and for four participants (2.2%) the traumatic incident had occurred less than six months prior to study participation.

3.1. Prevalence and severity of peritraumatic TI and TI during re-experiencing

For the total sample, the mean TIS–TI_{trauma} score was 26.71 (SD = 8.56), with scores ranging from 0 to 42. Findings suggest that 21.2% (n = 39) of study participants reported low TI during the traumatic incident (i.e. TIS–TI_{trauma} < 21); 26.6% (n = 49) moderate peritraumatic TI (i.e. TIS–TI_{trauma} between 21 and 27), and 52.2% (n = 96) reported extreme peritraumatic immobility (i.e. TIS–TI_{trauma} ≥ 28).

On average, TIS–$TI_{re\text{-}exp}$ scores were 24.33 (SD = 8.32), with scores ranging from 0–42. Findings suggest that 27.7% (n = 51) of study participants reported low TI during re-experiencing (i.e. TIS–$TI_{re\text{-}exp}$ < 21); 35.3% (n = 65) moderate TI during re-experiencing (i.e. TIS–$TI_{re\text{-}exp}$ 21–27), and 37.0% (n = 68) reported extreme immobility during re-experiencing (i.e. TIS–$TI_{re\text{-}exp}$ ≥ 28).

The occurrence of peritraumatic TI and TI during re-experiencing were moderately related ($\chi^2(4) = 70.273$, $p = < 0.001$, Cramer's $V = 0.437$). Of all participants, 59.2% (n = 107) participants reported the same degree of TI during trauma and re-experiencing, whereas 10.8% (n = 20) reported more and 29.8% (n = 55) reported less TI during re-experiencing than during the actual trauma (see Table 2).

Table 1
Trauma characteristics sample.

	Female *n (%)*	Male *n (%)*
Sexual abuse	70 (54.7)	11 (19.6)
Physical violence	33 (25.8)	23 (41.1)
Sudden (violent) death	10 (7.8)	6 (10.7)
Warzone experiences	0 (0.0)	7 (12.5)
Natural disaster/accident	3 (2.3)	3 (5.4)
Miscellaneous	12 (9.4)	6 (10.7)
Total	128 (69.6)	56 (30.4)

Note. Miscellaneous trauma: e.g. medical trauma or bullying.

3.2. Relationship between TI and PTSD symptoms

Overall, PSS-SR scores indicated severe PTSD symptoms: M = 30.92 (SD = 8.23; range: 15–50). TIS–TI_{trauma} scores were moderately correlated with PSS-SR scores (r = 0.240; p = 0.001) and strongly correlated with TIS–$TI_{re\text{-}exp}$ (r = 0.677; p < 0.001), while TIS–$TI_{re\text{-}exp}$ scores were moderately strong correlated with PSS-SR scores (r = 0.453; p < 0.001).

3.3. TI during re-experiencing as a mediator of the effect of peritraumatic TI on PTSD symptoms

The total effect model with TIS–TI_{trauma} as predictor and PSS-SR as outcome variable was significant (R^2 = 0.06, F (1,182) = 11.11, p = 0.001). The direct effect model with both TIS–TI_{trauma} and TIS–$TI_{re\text{-}exp}$ as predictors of PSS-SR scores was also significant (R^2 = 0.21, F (2, 181) = 24.53, p < 0.001). But note, that in this latter model TIS–TI_{trauma} was no longer a significant predictor of PSS-SR scores (path c': b = − 0.1228, SE = 0.0897, t = −1.371, p = 0.172). The indirect effect of TIS-TI_{trauma} on PTSD symptoms through TIS–$TI_{re\text{-}exp}$ was significant (path a × b: b = 0.3626, SE = 0.0773, 95% BootLLCI = 0.2240 and BootULCI = 0.5275). This suggests that the effect of TIS–TI_{trauma} on PSS-SR scores was fully mediated by TIS–$TI_{re\text{-}exp}$. The specificity analysis showed that the indirect effect of TIS-$TI_{re\text{-}exp}$ (X) on PSS-SR through TIS–TI_{trauma} (M) was not significant (b = −0.0831, SE = 0.0643, 95% BootLLCI = −0.2187 and BootULCI = 0.0317), strengthening the directionality of our results.

Table 2
Distribution of participants across TI categories.

Peritraumatic TI *n (%)*	TI during re-experiencing *n (%)*		
	Low	Moderate	Extreme
Low	26 (14.1)	10 (5.4)	3 (1.6)
Moderate	17 (9.2)	25 (13.6)	7 (3.8)
Extreme	8 (4.3)	30 (16.3)	58 (31.5)

Table 3
Results from regression models.

	B	SE	*t*	*p*	CI (lower)	CI (upper)
Model 1						
TIS–TI_{trauma} → TIS-$TI_{re\text{-}exp}$ (a)	0.6766	0.0545	12.396	< 0.001	0.5689	0.7843
TIS–$TI_{re\text{-}exp}$ → PSS-SR (b)	0.5360	0.0895	5.986	< 0.001	0.3793	0.7126
TIS–TI_{trauma} → PSS-SR (c′)	−0.1228	0.0895	−1.371	0.172	−0.2994	0.0593
TIS–TI_{trauma} → PSS-SR (c)	0.2398	0.0720	3.333	0.001	0.0978	0.3818
TIS–TI_{trauma} → TIS–$TI_{re\text{-}exp}$ → PSS-SR (a × b)	0.3626	0.0773			0.2240	0.5275
Model 2						
TIS–$TI_{re\text{-}exp}$ → TIS–TI_{trauma} → PSS-SR (a × b)	−0.0831	0.0643			−0.2187	0.0347

Notes. Model 1 = proposed model; Model 2 = specificity model; a = effect of X on M; b = effect M on Y; c = total effect of X on Y; c′ = direct effect of X on Y controlling for M. The standard error and 95% CI for a × b are obtained by bootstrap with 10.000 re-samples. TIS–TI_{trauma} = Tonic Immobility Scale–Tonic Immobility during trauma; TIS–$TI_{re\text{-}exp}$ = Tonic Immobility Scale-Tonic Immobility during re-experiencing the traumatic event; PSS-SR = Posttraumatic Stress Symptoms – Self Report; CI (lower) = lower bound of a 95% confidence interval; CI (upper) = upper bound of a 95% confidence interval; → = affects.

Regression results for paths a, b, c, and c' are presented in Table 3.

Explorative analyses were carried out to investigate whether gender (male vs. female), sexual trauma exposure (yes vs. no), and time of re-experiencing (within the last 6 months vs. longer than 6 months ago) affected our mediation model. Notably, the index of moderated mediation was non-significant for all three variables (gender: $b = -0.0406$, SE = 0.1320, 95% BootLLCI = − 0.2266 and BootULCI = 0.2923; sexual trauma exposure: $b = -0.1472$, SE = 0.1435, 95% BootLLCI = −0.4209 and BootULCI = 0.1324 and time of re-experiencing: $b = -0.1537$, SE = 0.1355, 95% = −0.4257 and BootULCI = 0.1006), indicating that none of these variables influenced the mediation model.

4. Discussion

The findings of this study showed that an overwhelming majority of outpatients suffering from PTSD reported having experienced TI in reaction to trauma. What is more, the greater part of patients reported TI during re-experiencing the traumatic incident. Peritraumatic TI and PTSD symptom severity were positively related. Importantly, TI during re-experiencing fully mediated the association between peritraumatic TI and PTSD symptom severity.

In line with previous work in clinical populations (Heidt et al., 2005), the prevalence of peritraumatic TI in our treatment-seeking PTSD sample was high: almost 80% of patients reported having experienced moderate or extreme peritraumatic TI. This percentage of people having experienced peritraumatic TI is much higher than the percentages found in most non-clinical samples (Bovin et al., 2008; Galliano et al., 1993; Hagenaars, 2016; Heidt et al., 2005). Our finding thus adds to the growing body of research implying that TI plays a pervasive role in PTSD. As the clinical status of PTSD in this treatment-seeking sample may have influenced the way participants reflected on the traumatic event and affected TI reports, these results must be viewed cautiously, though. It has been shown that reports of peritraumatic reactions are not stable over time (Marshall and Schell, 2002) and that the presence of PTSD symptoms inflates the reporting of peritraumatic reactions (Zoellner et al., 2001). Interestingly, in a non-treatment seeking PTSD population prevalence of peritraumatic TI was much lower (25.3%; Hagenaars, 2016), suggesting that especially in treatment-seeking PTSD patients the reports of peritraumatic reactions might be inflated. However, in comparison to the community sample of Hagenaars (2016), our sample had a larger proportion of women and higher PTSD severity. Notably, both female gender (Kalaf et al., 2015) and PTSD symptom severity have been positively linked to peritraumatic TI (Bovin et al., 2008; Heidt et al., 2005; Humphreys et al., 2010; Kalaf et al., 2015; Maia et al., 2015; Portugal et al., 2012; Rocha-Rego et al., 2009). In any case, the high report of peritraumatic TI by treatment-seeking PTSD patients suggests that clinicians should pay attention to this trauma response. Psycho-education about the automatic, non-volitional nature of peritraumatic TI may address commonly experienced feelings of guilt and self-blame regarding immobility reactions during trauma (Bovin et al., 2014).

Remarkably, many PTSD patients reported moderate or extreme TI during re-experiencing the traumatic event. Previous studies already reported TI during stress inductions, such as trauma scripts (Volchan et al., 2011), unpleasant picture viewing (Alves Rde et al., 2014), and eye closure (Fragkaki et al., 2016). Now, TI also proved to be present during re-experiencing the trauma, a highly relevant PTSD stressor. This is of great relevance, because TI may elicit feelings of uncontrollability and inescapability (Bovin et al., 2008), which are considered to be relevant in the aetiology of PTSD (Foa et al., 1992). As such, re-occurring TI might be an important maintaining factor of PTSD. Future work should investigate whether the occurrence of TI during re-experiencing symptoms is indeed related to a worse course of PTSD.

Previous studies suggested that peritraumatic TI is related to PTSD symptom severity (Bovin et al., 2008; Hagenaars, 2016; Heidt et al., 2005; Humphreys et al., 2010; Kalaf et al., 2015; Maia et al., 2015; Portugal et al., 2012; Rocha-Rego et al., 2009). In line, we found a moderate positive correlation between peritraumatic TI and PTSD symptom severity. Previous studies also found a relationship between peritraumatic TI and TI in response to a stress-induction (Fragkaki et al., 2016; Volchan et al., 2011), which was again confirmed by our findings. By testing all variables in one model, we found a possible explanation for the previously reported effects of peritraumatic TI on PTSD. That is, TI during re-experiencing the traumatic event fully mediated the relationship between peritraumatic TI and PTSD symptoms. Thus, it appears that those who experience peritraumatic TI are likely to experience TI during subsequent stressors, and that especially this re-occurring TI response is related to PTSD symptom severity. This would imply that more attention, in both research and clinical care, should be paid to post-trauma TI reactions.

Our study has several limitations. First, the use of cross-sectional self-reports precludes us from establishing the exact relation between TI and PTSD. Importantly, causality cannot be inferred. Rather, our findings hint towards an alternative model that should be tested in future studies. One alternate explanation for the finding that TI during re-experiencing mediates the effect of peritraumatic TI on PTSD symptoms severity is that TI during re-experiencing is not so much a predictor but rather a correlate of PTSD severity. Prognostic studies could shed more light on the influence of TI during re-experiencing on the course of PTSD. Future work should also consider assessing TI during symptom provocation by a combination of both self-report and physiological measures (e.g. movement on a stabilometric platform). This would provide more information on whether the subjective feeling of being immobile, the objectively assessed physical immobility, or the

combination of the two is most relevant in the TI and PTSD relationship. Second, to limit burden to patients and ease implementation, we added only the two TIS measures to the routine outcome measurement. Previous studies investigating TI concurrently with other predictors were inconclusive as to whether TI uniquely predicts PTSD symptom severity. The assessment of related and convergent constructs (such as peri- and posttraumatic dissociation or trait anxiety), could have given us more information on the specificity of the TI and PTSD relationship.

The results of the current study both corroborate and extend previous research on the prevalence of TI in PTSD patients. The occurrence of TI during re-experiencing and its effect on PTSD symptoms highlights the importance of further studying TI at different stages post trauma. We propose a mediation model including peritraumatic TI as well as TI during re-experiencing and made a first step in testing this model. Our findings highlight the influence of post trauma TI on PTSD symptoms, and it appears crucial to learn whether this re-occurring TI hampers recovery.

Role of the funding source

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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