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Mild traumatic brain injury characteristics do not negatively influence cognitive processing therapy attendance or outcomes

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ABSTRACT

Some providers have expressed hesitation about the appropriateness of PTSD treatment for veterans with a history of mild traumatic brain injury (mTBI), given concerns that TBI-related sequelae may negatively affect PTSD treatment and/or should be the focus of treatment instead. However, research suggests that those with a history of mTBI can benefit from evidence-based PTSD treatment. To extend these findings, we examined whether specific mTBI injury markers were associated with PTSD treatment attendance and response. Iraq/Afghanistan-era veterans with PTSD and history of mTBI (N = 88) all received Cognitive Processing Therapy (CPT; either standard CPT without the trauma account or SMART-CPT, a modified version of CPT that included cognitive rehabilitation strategies). Analyses examined whether time since injury, presence of loss of consciousness (LOC) or posttraumatic amnesia (PTA), and number and mechanism of mTBIs were associated with treatment attendance or response. None of the five injury variables examined were associated with number of treatment sessions attended. Multilevel modeling indicated that injury variables did not moderate treatment response (across treatment conditions) in terms of change in PTSD and depression symptoms. There was a three-way interaction showing that individuals who denied ever experiencing LOC exhibited a greater decrease in PTSD and depression symptoms in standard CPT relative to those in the SMART-CPT. Thus, a history of mTBI should not preclude individuals from receiving standard CPT, regardless of injury characteristics. In fact, PTSD treatment should often be a first line of treatment for these veterans, given evidence of a mental health etiology to persistent post-concussive symptoms.

1. Introduction

Estimates suggest that Iraq/Afghanistan-era veterans develop posttraumatic stress disorder (PTSD) at a higher rate than the general population (Fulton et al., 2015; Kessler et al., 2005; Kilpatrick et al., 2013; Ramchand et al., 2010; Schell and Marshall, 2008). Thus, it is paramount to treat PTSD, particularly in Iraq/Afghanistan-era veterans, in order to reduce its significant burden on individuals, families, and society. Two types of empirically-supported cognitive behavioral therapies (CBT) - prolonged exposure (PE) and cognitive processing therapy (CPT) - are considered the gold standard for PTSD treatment (American Psychological Association, 2017; Veterans Affairs/Department of Defense [VA/DoD], 2017). Despite the abundance of literature supporting their effectiveness, only a small percentage of individuals diagnosed with PTSD initiate and complete CPT or PE (Maguen et al., 2019; Rosen et al., 2019; Sripada et al., 2018). Many factors across institutional, provider, and patient levels contribute to this issue, including concern among providers about the appropriateness of these treatments for individuals with comorbid conditions (Doran et al., 2018; Osei-Bonsu et al., 2017), including history of traumatic brain

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injury (TBI; Cook et al., 2013, 2014; Sayer et al., 2009).

It is not uncommon for Iraq and Afghanistan Veterans to experience a TBI, with more than 80% of TBIs sustained classified as mild in severity (Defense and Veterans Brain Injury Center, 2017). Mild TBI (mTBI) is defined as a blow to the head resulting in an alteration or loss of consciousness less than 30 min, posttraumatic amnesia lasting less than 24 h, and no findings on standard neuroimaging (VA/DoD, 2016). Mild TBI is equivalent to a concussion, and the expected trajectory of recovery is a complete resolution of TBI-related sequelae and return to baseline functioning within three months (e.g., Belanger et al., 2005; Carroll et al., 2004). However, a minority of individuals with a history of mTBI report cognitive, somatic, and psychiatric complaints well beyond the acute phase (Iverson, 2005). The overwhelming majority of the literature supports a mental health etiology to these ongoing post-concussive symptoms (e.g., Belanger et al., 2010; Lagarde et al., 2014; Meares et al., 2011).

The contribution of mental health factors to ongoing symptoms in individuals with a history of mTBI is not surprising since post-concussive complaints are often non-specific to TBI and significantly overlap with those observed in psychiatric conditions, particularly PTSD (e.g., difficulty making decisions, slowed thinking, fatigue, irritability). Comorbidity between PTSD and TBI is common in Iraq/Afghanistan-era veterans; approximately 42–73% of Iraq/Afghanistan-era veterans that have sustained a TBI also have a diagnosis of PTSD (Lew et al., 2008; Taylor et al., 2012). Given symptom overlap and the primary role of psychiatric factors in prolonged recovery from post-concussive symptoms, treatment of mental health conditions is warranted in individuals with comorbid PTSD/mTBI. In fact, the VA/DoD clinical practice guideline for mTBI (2016) recommends that comorbid psychiatric disorders such as PTSD should be assessed and treated in those with a history of mTBI. Similarly, the VA/DoD clinical practice guideline for PTSD (2017) recommends that comorbid conditions should not preclude individuals from receiving recommended PTSD treatments (e.g., PE, CPT).

Despite these recommendations, providers often express hesitation about the appropriateness of trauma-focused PTSD treatment for veterans with a history of TBI, given concerns that symptoms attributed to TBI may negatively affect PTSD treatment and/or should be the focus of treatment instead. For example, providers reported concern about reduced cognitive ability "due to TBI" impacting treatment, including slowing down treatment and requiring greater individual attention and repetition in order to benefit from PTSD treatments (Cook et al., 2013, 2014; Sayer et al., 2009). Concern about CPT in particular was noted by some providers surveyed, who stated they were not providing CPT to veterans with a history of TBI due to its reliance on cognitive skills, including abstract thinking and memory, and significant amount of written assignments (Cook et al., 2013, 2014; Raza and Holohan, 2015; Sayer et al., 2009). However, withholding PTSD treatment from these individuals is problematic, as cognitive symptoms may be misattributed to TBI when in fact they may be better accounted for by PTSD and/or other commonly co-occurring psychological disorders (e.g., depression, substance use disorder), and PTSD treatment can actually improve cognitive difficulties (Jak, 2017). Confusion about the etiology of symptoms can also lead to referrals to other kinds of treatment or providers (e.g., TBI specialist) when PTSD and related mental health conditions may actually be the most appropriate target of treatment for the constellation of symptoms observed.

Among 40 VA providers surveyed in one study, there was a general consensus that research is needed regarding the efficacy of the evidence-based PTSD treatments for veterans with comorbid history of mTBI (Sayer et al., 2009), consistent with recommendations from a recent review paper (Ackland et al., 2019) and VA/DoD guidelines (2017) calling for studies on this topic to provide better guidance to clinicians and providers. There is currently a small body of literature indicating that those with a history of mTBI can benefit from evidence-based, trauma-focused PTSD treatment, including PE (Sripada et al., 2013; Wolf et al., 2015) and CPT (Chard et al., 2011; Walter et al., 2014). More specifically, results across studies thus far have demonstrated that TBI status (comparing those with and without a history of TBI) was not associated with differences in response to PE or CPT (Ragsdale and Voss Horrell, 2016; Sripada et al., 2013), and that the magnitude of treatment response observed in those with a history of TBI was comparable to those well documented in the literature across numerous PTSD treatment studies (Chard et al., 2011; Walter et al., 2014; Wolf et al., 2015). In addition, Davis et al. (2013) examined Iraq/Afghanistan-era veterans with and without mTBI and found a lack of group differences in CPT treatment dropout rates, indicating that CPT is tolerable for veterans with PTSD and a history of mTBI.

However, it may be the case that individuals who sustained a mTBI with particular injury characteristics (e.g., presence of loss of consciousness [LOC] or posttraumatic amnesia [PTA]) or greater number of mTBIs have poorer PTSD treatment outcomes, though no studies to date have examined this possibility. An abundance of studies have examined whether certain injury markers (e.g., LOC or PTA) or greater TBI burden were predictive of poorer recovery and functional outcomes following mTBI. Although this literature is mixed, much of the evidence indicates that injury markers are not associated with poorer outcomes past the acute phase of recovery following mTBI, whereas mental health symptoms are a strong predictor of worse outcomes and persistence of post-concussive symptoms (Carroll et al., 2004; Iverson et al., 2017; McCrea, 2008). Therefore, the primary goal of the present study was to extend the emerging literature on mTBI and PTSD treatment outcomes by examining whether various injury characteristics of mTBI (number of lifetime mTBIs [1–2 vs. 3 or more], time since most recent injury, presence of LOC, presence of PTA, mechanism of injury [blast vs. other]) were associated with PTSD treatment attendance and response.

The aims of the present study were addressed by performing a secondary analysis of a randomized controlled trial of standard CPT (without the trauma account) vs. modified CPT that included compensatory cognitive rehabilitation strategies (SMART-CPT). In brief, primary outcomes of the clinical trial demonstrated that there were no differences in PTSD symptom change across treatment conditions; however SMART-CPT was associated with greater improvement on some cognitive measures (i.e., attention/working memory, verbal learning/memory, novel problem solving; Jak et al., 2019). In the present study, it was hypothesized that the injury markers examined would not be associated with CPT attendance or response. Change in PTSD symptoms was of primary interest in terms of treatment response, though change in depression symptoms was also examined as a secondary outcome.

2. Method

2.1. Participants

Participants were enrolled in the clinical trial (N = 100) if they were Iraq/Afghanistan-era veterans with a current diagnosis of PTSD and history of mild-to-moderate TBI, reported current subjective cognitive complaints, and were stable on psychiatric medication for at least six weeks. Exclusion criteria included current substance dependence, suicidal intent or attempt in the prior month, current psychotic disorder, dementia, non-English speaking, current participation in other intervention studies, or more than five prior sessions of CPT or Cognitive Symptom Management and Rehabilitation Therapy (CogSMART; Twamley et al., 2014, 2015). Since the present study is focused on mTBI (LOC ≤ 30 min, PTA ≤ 24 h; VA/DoD Management of Concussion-mTBI Working Group, 2016), the 6 participants who reported experiencing a moderate TBI (based on the longest length of LOC or PTA reported) were excluded from current secondary analyses.[1]

[1] All results reported were consistent when including the six participants who

Furthermore, to remain consistent with previous studies of TBI and PTSD treatment adherence/outcomes, only participants who initiated treatment (i.e., attended at least one session) were included in present analyses (Davis et al., 2013; Wolf et al., 2015); six participants did not initiate treatment after enrollment into the study. The sample of 88 participants with PTSD and a history of only mTBI included in the present analyses was primarily male (88.6%), with an average age of 34.89 (*SD* = 8.23), and a mean of 13.68 years of formal education (*SD* = 1.90). The sample was 47.7% Caucasian and 22.7% identified as Hispanic.

2.2. Procedure

The clinical trial (clinicaltrials.gov identifier NCT01943162) procedures are more thoroughly described elsewhere (see Jak et al., 2015, 2019). The study was approved by the local Institutional Review Board. Participants who qualified for the study and provided informed consent were randomized to one of two 12-week treatment conditions: 1) standard CPT (without the trauma account) or 2) SMART-CPT, a hybrid treatment that included all of the standard content of CPT as well as aspects of CogSMART, including psychoeducation about TBI and compensatory cognitive rehabilitation strategies focused on attention, memory, and executive functioning. In addition, in SMART-CPT, the CPT content remained standard but was modified to include more concrete language, repetition of key points via written summaries and brief reviews, and simplified/restructured worksheets. A trained doctoral-level psychologist delivered both treatments and received individual supervision from a VA CPT trainer for the duration of the trial. Ten percent of the audio-recorded sessions were randomly selected and rated by the VA CPT trainer and all of these sessions were rated 80% or better in adherence. Participants completed three assessments: baseline, immediately following treatment completion, and 3 months later (6 months after baseline assessment). PTSD, depression, and post-concussive symptoms were measured at each of the three assessments; PTSD symptoms were also measured weekly during treatment. TBI history details were obtained during the baseline assessment.

2.3. Measures

Symptom questionnaires. PTSD symptoms were measured using the 17-item PTSD Checklist - Specific Trauma (PCL-S; Weathers et al., 1993). PCL-S was the primary outcome measure and was administered at baseline, weekly over 12 weeks of treatment, posttreatment, and 3-month follow up evaluations (up to 15 time points). The 21-item Beck Depression Inventory-II (BDI-II; Beck et al., 1996) was used to measure depressive symptoms at each of the three assessments and was a secondary outcome of interest. The 22-item Neurobehavioral Symptom Inventory (NSI; Cicerone & Kalmar, 1995) was used as a measure of post-concussive symptoms, including emotional, cognitive, somatic, and vestibular symptoms.

TBI characteristics. Self-reported TBI history details were obtained via the Warrior Administered Retrospective Casualty Assessment Tool (WARCAT; Terrio et al., 2009). Specific injury characteristics that were obtained and used for the present analyses included number of lifetime mTBIs experienced, years since most recent TBI, presence of LOC, presence of PTA, and mechanism of injury (blast vs. other) for any TBI experienced. Number of mTBIs was not normally distributed and was dichotomized to group those who experienced three or more together (1–2 vs. 3 or more), consistent with the majority of the TBI literature examining this injury variable (e.g., Dretsch et al., 2015; Guskiewicz et al., 2003, 2007; Iverson et al., 2004; Spira et al., 2014).

2.4. Statistical analyses

First, relationships between the five injury variables and number of sessions attended were examined using non-parametric tests (Mann-Whitney U tests and Spearman's correlations) due to non-normality of the session attendance variable. Next, multilevel modeling (MLM) analyses were used to examine whether injury variables predicted treatment response (change in PCL-S scores). Prior work on this study also implemented MLM to examine outcomes (Jak et al., 2019; Crocker et al., 2018). Previous studies have often used more traditional statistical approaches such as change scores and repeated measures ANOVAs that use casewise deletion for missing data; however, MLM is more advantageous because it includes participants with missing data (including those who dropped out of treatment), thus reducing bias and increasing statistical power (Schafer and Graham, 2002; Singer and Willett, 2003; Woodard, 2017). Additionally, MLM can take into account that repeated observations across time are nested within individuals and are not independent. The current analyses used a full information likelihood method, which included all available data (even if a participant had missing data or dropped out early).

In terms of change in PTSD symptoms, the primary treatment outcome of interest, initial MLM testing using the 15 possible PCL-S time points examined individual-level random effects of intercept and slope to model variability in baseline PTSD symptoms and treatment response, respectively. Estimates of these random effects were significant and model fit improved when both random effects were included. Time was modeled as a continuous variable. Models analyzed each injury variable separately to test whether the injury variable by time interaction significantly predicted change in PCL-S scores. All models included fixed effects of time, treatment condition, injury variable, treatment condition x time, injury variable x time, as well as baseline depression and post-concussive symptom scores (BDI-II and NSI) as covariates. Estimates of MLM effect sizes are reported as *r* values (small = 0.10; medium = 0.30; large = 0.50).

Analyses also explored three-way interactions with treatment condition (standard CPT vs. SMART-CPT) to examine whether any injury variable moderated the interaction between treatment condition and time on change in PTSD symptoms. Therefore, the three-way interaction (injury variable x time x treatment condition) as well as the injury variable x treatment condition interaction (to include all relevant two-way interactions) were added to the models described above. Secondary analyses examined change in depression symptoms over three possible time points. These models repeated the MLM analyses detailed above but used BDI-II as the outcome and included only intercept as a random effect based on initial model testing since BDI-II was only administered at three time points. All analyses were conducted in SPSS v.25.0.

3. Results

In terms of number of lifetime mTBIs reported, 47.7% of the sample reported experiencing three or more mTBIs and the mean years since most recent mTBI was 5.20 (*SD* = 3.46). Across all mTBIs experienced, 72.7% of participants reported presence of LOC, 52.3% reported presence of PTA, and 33% reported a history of a blast-related mTBI. Regarding treatment attendance, number of sessions attended was unrelated to any of the injury variables: number of lifetime mTBIs (1–2 vs. 3+), $U = 861.50$, $p = .339$, $r = 0.10$; presence of LOC, $U = 592.00$, $p = .222$, $r = 0.13$; presence of PTA, $U = 744.50$, $p = .095$, $r = 0.18$; history of blast-related mTBI, $U = 816.50$, $p = .707$, $r = 0.04$; and years since most recent mTBI, $r_s = 0.04$, $p = .692$.

For the MLM results examining whether injury variables predicted treatment response in terms of PTSD symptoms, there was a main effect of time for each model (all p's ≤ 0.001; see Table 1), indicating a

(*footnote continued*)
reported experiencing a moderate TBI. It is possible that the reported findings generalize to moderate TBI, though future research in a larger sample of individuals with a history of moderate TBI is warranted.

Table 1
Parameter estimates of multilevel models predicting change in PCL-S scores.

	Number of mTBIs (1–2 vs. 3+)			LOC presence ever			PTA presence ever			Blast-related TBI ever			Years since most recent mTBI		
	b (SE)	*p*	*r*	*b* (SE)	*p*	*r*	*b* (SE)	*p*	*r*	*b* (SE)	*p*	*r*	*b* (SE)	*p*	*r*
Two-way interaction															
Time	−1.48 (.29)	< **.001**	.53	−1.28 (.36)	**.001**	.41	−1.51 (.29)	< **.001**	.54	−1.45 (.26)	< **.001**	.57	−1.44 (.33)	< **.001**	.47
Tx condition	−1.07 (1.76)	.545	.07	-.93 (1.80)	.606	.06	-.70 (1.77)	.693	.04	−1.17 (1.74)	.501	.07	−1.11 (1.74)	.526	.07
Injury variable	.76 (1.72)	.660	.05	.51 (2.00)	.799	.03	-.15 (1.75)	.933	.01	-.96 (1.81)	.597	.06	.05 (.25)	.830	.02
Tx condition x time	.13 (.32)	.688	.05	.05 (.32)	.878	.02	.14 (.32)	.662	.05	.09 (.31)	.780	.03	.09 (.31)	.785	.03
Injury variable x time	.20 (.31)	.518	.08	-.05 (.35)	.897	.02	.23 (.31)	.464	.09	.30 (.33)	.359	.11	.02 (.04)	.707	.05
Three-way interaction															
Tx condition x time x injury variable	-.26 (.63)	.682	.05	−1.58 (.69)	**.026**	.28	.18 (.63)	.774	.04	-.14 (.66)	.830	.03	.00 (.09)	.961	.01

p ≤ .001 in bold; Abbreviations: PCL-S = Posttraumatic Stress Disorder Checklist - Specific Trauma; mTBI = mild traumatic brain injury; LOC = loss of consciousness; PTA = post-traumatic amnesia; Tx condition = treatment condition (0 = CPT, 1 = SMART-CPT).

significant decrease in PTSD symptoms. Those who completed treatment demonstrated an average decrease of 15.18 points (*SD* = 15.06). Across all participants, including those who dropped out prior to treatment completion, an average decrease of 11.15 points (*SD* = 14.10) was observed from pre-treatment to last PCL-S observation (i.e., the final PCL-S score obtained at the post-treatment assessments or obtained at the last treatment session attended if the participant did not complete treatment). Thus, participants with mTBI exhibited clinically significant and reliable reductions in PTSD symptoms (i.e., at least a 10-point decrease in PCL-S scores; Monson et al., 2008a,b). However, none of the injury variable × time interactions were significant (all *p*'s > 0.358; see Table 1), indicating that mTBI injury variables were not predictive of change in PTSD symptoms over time.

The follow-up MLM analyses examining the three-way interaction between injury variables, time, and treatment condition indicated that the only significant three-way interaction was for presence of LOC, $b = -1.58$, SE = 0.69, $p = .026$ (see Table 1). Probing this interaction indicated that there was a trend for a treatment condition by time interaction for those without LOC ($b = 1.16$, SE = 0.58, $p = .062$), whereas the condition by time interaction was not significant for those with a history of LOC ($b = -0.34$, SE = 0.36, $p = .351$). The pattern of results indicated that those who denied ever experiencing LOC exhibited a greater reduction in PTSD symptoms in the standard CPT condition relative to the SMART-CPT condition. Those who reported experiencing LOC did not appear to differentially benefit from standard CPT compared to SMART-CPT in PTSD symptom reduction.

Results from MLMs examining change in depression symptoms were consistent with those observed for PTSD symptoms (see Table 2). None of the injury variable × time interactions were significant, but there was similarly a main effect of time for each two-way model (all *p*'s < 0.027), indicating a significant decrease in depression symptoms. In addition, a significant three-way interaction was also observed between presence of LOC, time, and treatment condition, $b = -0.61$, SE = 0.27, $p = .030$. Probing this interaction indicated that there was a trend for a treatment condition by time interaction for those without LOC ($b = 0.47$, SE = 0.23, $p = .061$), whereas the condition by time interaction was not significant for those with a history of LOC ($b = -0.15$, SE = 0.13, $p = .282$). The pattern of results was the same as that observed for PTSD symptoms, such that those who denied ever experiencing LOC exhibited a greater reduction in depression symptoms in the standard CPT condition relative to the SMART-CPT condition. Those who reported experiencing LOC did not appear to differentially benefit in terms of depression symptom change between standard CPT and SMART-CPT.

4. Discussion

The primary goal of the present study was to add to the small but growing empirical evidence that CBT approaches for treating PTSD are effective for Veterans with a history of mTBI, regardless of the nature of the injury characteristics. In terms of treatment attendance, none of the injury variables examined were associated with number of sessions attended. Regarding treatment response, all two-way interactions between injury variables and time predicting change in PTSD and depression symptoms were nonsignificant; thus, none of the five injury variables moderated treatment response (across treatment conditions). Follow-up analyses showed that only one three-way interaction was

Table 2
Parameter estimates of multilevel models predicting change in BDI-II scores.

	Number of mTBIs (1–2 vs. 3+)			LOC presence ever			PTA presence ever			Blast-related TBI ever			Years since most recent mTBI		
	b (SE)	*p*	*r*	*b* (SE)	*p*	*r*	*b* (SE)	*p*	*r*	*b* (SE)	*p*	*r*	*b* (SE)	*p*	*r*
Two-way interaction															
Time	-.42 (.11)	< **.001**	.48	-.32 (.14)	**.026**	.31	-.52 (.10)	< **.001**	.62	-.32 (.10)	**.002**	.42	-.40 (.14)	**.007**	.29
Tx condition	2.26 (1.86)	.228	.14	2.68 (1.88)	.157	.16	2.21 (1.84)	.234	.13	2.37 (1.84)	.200	.14	2.49 (1.84)	.180	.14
Injury variable	-.56 (1.84)	.760	.03	-.84 (2.13)	.693	.04	−1.52 (1.83)	.410	.09	1.02 (1.93)	.597	.06	-.18 (.27)	.491	.07
Tx condition x time	.02 (.12)	.869	.02	-.01 (.12)	.956	.01	.12 (.11)	.280	.16	.00 (.11)	.976	.00	.02 (.13)	.870	.02
Injury variable x time	.04 (.11)	.744	.05	-.08 (.13)	.535	.09	.08 (.11)	.450	.11	-.24 (.13)	.062	.26	.01 (.02)	.668	.05
Three-way interaction															
Tx condition x time x injury variable	.27 (.23)	.261	.16	-.61 (.27)	**.030**	.30	.16 (.22)	.452	.11	-.37 (.25)	.135	.21	-.07 (.04)	.076	.19

p ≤ .001 in bold; Abbreviations: BDI-II = Beck Depression Inventory-II; mTBI = mild traumatic brain injury; LOC = loss of consciousness; PTA = post-traumatic amnesia; Tx condition = treatment condition (0 = CPT, 1 = SMART-CPT).

significant, such that LOC presence moderated the relationship between treatment condition and time. However, this finding was driven by individuals who denied ever experiencing LOC, who exhibited a greater decrease in PTSD and depression symptoms (better response) in the CPT only condition relative to those in the SMART-CPT condition. In general, veterans experienced a clinically significant reduction in PTSD symptoms, regardless of injury characteristics.

Taken together, there was no evidence that injury markers or indices of greater injury burden were associated with PTSD treatment attendance and response, indicated by generally small and non-significant effects. These findings are consistent with and extend research thus far showing that individuals with a history of TBI can engage in and benefit from evidence-based treatments for PTSD (Ragsdale and Voss Horrell, 2016; Sripada et al., 2013; Wolf et al., 2015), including CPT (Chard et al., 2011; Davis et al., 2013; Walter et al., 2014). Previous research specifically examining treatment adherence showed that individuals with and without a history of mTBI demonstrated comparable dropout rates from CPT (Davis et al., 2013), and Wolf et al. (2015) found no difference in rates of PE completion between those with a history of mild versus moderate-to-severe TBI. We also previously reported that TBI variables were not associated with treatment dropout in this study, whereas poorer performance on measures of executive functioning did confer risk for early termination of treatment (Crocker et al., 2018). Present results extend these findings to show that various injury characteristics within mTBI do not appear to negatively impact treatment attendance. Therefore, taken together, the available evidence thus far does not support provider concerns that individuals with a history of mTBI, including those who sustain particular types of injuries, cannot tolerate standard PTSD interventions.

The current study also extends previous research demonstrating the effectiveness of PTSD treatment in individuals with a history of TBI to show that injury markers do not appear to reduce the response to standard CPT in a sample of veterans with a history of mTBI. We could locate only one previous study that considered an injury marker in relation to PTSD treatment. Time since worst injury was unrelated to the decrease in PTSD symptoms observed across PE in a heterogeneous sample of veterans with a range of TBI severities (Crawford et al., 2017), consistent with the present results of CPT. Although in the current study one injury marker interacted with treatment condition and time to moderate treatment response, the finding warrants replication, as there was a small number of individuals without LOC who received standard CPT ($n = 7$). It is possible that individuals with an injury involving only an alteration of consciousness (rather than LOC) do not need the additional cognitive rehabilitation components that were incorporated into the SMART-CPT condition; they instead appear to benefit more when the entire focus of treatment was on CPT skills that targeted only PTSD and related mental health symptoms (which is the standard CPT treatment delivered in VA PTSD clinics) rather than strategies that target both PTSD and cognitive complaints. Regardless, those who sustained a mTBI involving LOC did not differentially benefit from standard CPT vs. SMART-CPT in terms of reductions in PTSD and depression symptoms.

Moreover, veterans with a history of mTBI in the present study responded well to trauma-focused, empirically-supported PTSD treatment, exhibiting clinically significant decreases in PTSD symptoms, consistent with the magnitude of change observed in numerous studies of CPT (e.g., Chard et al., 2010; Resick et al., 2017; Monson et al., 2006). Therefore, a history of mTBI should not preclude individuals from receiving CPT, regardless of injury characteristics. In fact, PTSD treatment should often be a first line of treatment for these veterans, given evidence of a mental health etiology to persistent post-concussive symptoms (e.g., Belanger et al., 2010; Lagarde et al., 2014; Meares et al., 2011). Thus far, evidence challenges providers' assumptions that veterans with a history of TBI cannot benefit from treatments such as CPT that are primarily cognitive in nature (e.g., Cook et al., 2013, 2014; Raza and Holohan, 2015; Sayer et al., 2009) and supports current recommendations for not withholding these treatments from these veterans (VA/DoD, 2017). In fact, withholding effective treatment for PTSD may have negative consequences for individuals (e.g., poorer functioning, increased suicidality) as well as society (e.g., increased healthcare costs related to untreated conditions and/or receiving unnecessary treatments).

A limitation of the present study was the use of a self-report measure to obtain TBI history details without the availability of medical records from the time of injury to corroborate details in most cases. However, self-report is the most common method employed to obtain information about TBI history in this population, as medical records from the time of injury are rarely available. Similarly, a self-report measure of PTSD symptoms was used to assess symptom change over time using DSM-IV-based criteria. However, there is research indicating that the PCL shows high correspondence with clinician-assessed measures of PTSD symptoms as well as measures using DSM-5 PTSD criteria (Bovin et al., 2016; Monson et al., 2008a,b; Weathers et al., 2018; Wortmann et al., 2016).

Despite the limitations of self-report, a strength of the present study was the use of a structured interview to obtain TBI history details, rather than the methods of several previous studies involving the use of retrospective VA chart reviews (e.g., Davis et al., 2013; Ragsdale and Horrell, 2016; Sripada et al., 2013). This latter approach made it difficult for previous researchers to determine TBI severity, thus study samples involved a range of severities. In contrast, the present study was strengthened by examining a homogenous sample of only veterans with a history of mTBI. Future research would benefit from studies that are adequately powered to determine if present findings generalize to veterans with a history of moderate-to-severe TBI and similarly, if results generalize to other empirically-supported PTSD treatments such as PE. The study makes important contributions to the literature indicating that veterans with a history of mTBI can benefit from CPT, regardless of the nature of their injuries.

Declarations of interest

None.

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