Post-Traumatic Stress Symptoms and Depression Strongly Associated with Emotional Regulation Deficits in Individuals with Traumatic Brain Injury

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ABSTRACT

INTRODUCTION: Traumatic brain injury (TBI) is frequently linked to psychological challenges, including post-traumatic stress symptoms (PTSS), depressive symptoms, and emotional regulation difficulties. Despite the high prevalence of these issues in individuals with TBI, research on their interrelationships remains limited. This study aims to investigate the prevalence of PTSS, depressive symptoms, and emotional regulation difficulties among individuals with TBI and to explore the relationships between these challenges. **MATERIALS AND METHODS**: A cross-sectional study was conducted with 150 individuals with a history of TBI. Participants completed self-report measures: the Post-Traumatic Stress Disorder Checklist (PCL), the Patient Health Questionnaire (PHQ-9), and the Emotion Regulation Questionnaire (ERQ). Descriptive statistics and correlation tests were employed to assess the prevalence and interrelationships between the variables. **RESULTS:** The results revealed that 80.7% of participants met the clinical threshold for PTSS, 83.3% exhibited moderate to severe depressive symptoms, and 32% demonstrated low cognitive reappraisal scores. Additionally, 74% of participants showed medium to high levels of expressive suppression. Strong positive correlations were found between expressive suppression and PTSS (Spearman's ϱ=0.532, $p<0.001$) and between PTSS and depressive symptoms (Spearman's ϱ=0.728, $p<0.001$). **CONCLUSION:** The study highlights significant psychological challenges in individuals with TBI, emphasizing the role of emotional regulation in the co-occurrence of PTSS and depressive symptoms. These findings suggest that emotional regulation strategies, particularly expressive suppression, play a crucial role in the psychological outcomes of TBI. Future research should focus on longitudinal studies to better understand these relationships and their long-term implications.

KEYWORDS: Traumatic brain injury, post-traumatic stress symptoms, depressive symptoms, emotional regulation, expressive suppression.

INTRODUCTION

Traumatic brain injury (TBI) is a global public health challenge, affecting an estimated 69 million individuals annually.[1,2] TBI results in both immediate and long-term consequences that affect not only the physical and cognitive functions but also the emotional and psychological health of individuals.[3] By 2030, TBI is projected to be one of the leading causes of injury-related fatalities and disabilities, burdening healthcare systems worldwide.[2]

In Malaysia, TBI is a leading cause of intensive care unit (ICU) admissions, primarily due to road traffic accidents (RTAs).[4] However, there is a lack of comprehensive national data on TBI, particularly regarding non-RTA causes such as falls, sports injuries, and abuse. Despite the efforts of the National Trauma Database Malaysia (NTrD) overseen by the Ministry of Health, reports are infrequent and outdated, with the most recent data published in 2011. The high prevalence of RTAs, particularly among younger males in the 15-24

age group,[4,5] underscores the need to address the long-term consequences of TBI in this high-risk demographic. Although survival rates in trauma cases are relatively high, limited research exists on the psychological outcomes of TBI survivors, including post-traumatic stress symptoms (PTSS), depression, and emotional regulation difficulties.[6] This gap in research highlights the need for further investigation into how TBI affects the mental and emotional well-being of individuals, especially those in vulnerable age groups.

TBI is widely associated with neuropsychiatric complications, including PTSS, depressive symptoms, and emotional regulation issues, all of which significantly affect recovery and quality of life.[7,8] PTSS, once thought to be uncommon following TBI, is increasingly recognized as a significant consequence of brain injuries, even in individuals who do not explicitly recall the traumatic event.[9,10] Individuals with mild traumatic brain injury (mTBI) are at an increased risk of developing PTSS and post-traumatic stress disorder (PTSD) compared to those with other injuries or no TBI.[11,12,13] Meta-analyses and large cohort studies indicate that the prevalence of PTSD following mTBI in civilian populations ranges from 12% to 16% within the first year of the post-injury period. [14]

PTSS and depressive symptoms are commonly observed in TBI survivors, and together they complicate the recovery process. These symptoms are often interrelated, with the presence of one exacerbating the severity of the other, leading to prolonged recovery trajectories.[10,16,17] Emotional dysregulation is another prevalent issue for TBI survivors, often co-occurring with PTSS and depressive symptoms, further contributing to functional impairments and hindering rehabilitation efforts.[18,19,20] Brain damage in areas such as the prefrontal cortex, amygdala, and ventromedial prefrontal cortex plays a key role in these impairments.[21] Lesions in the prefrontal cortex for example, are associated with deficits in executive functions like planning, decision-making, and impulse control.[22] Damage to the amygdala has been shown to significantly alter emotional responses, particularly fear processing, leading to increased emotional reactivity.[23] Furthermore, lesions in the ventromedial prefrontal cortex impact reward-based decision-making and risk evaluation, often leading to maladaptive behaviours.[22,23] These disruptions in key brain regions responsible for emotional and cognitive regulation highlight the complexity of recovery for TBI survivors.

Despite significant global research, TBI studies in Malaysia predominantly focus on its immediate physiological consequences, such as neuroinflammation and mitochondrial dysfunction.[6,24] However, the long-term psychological impacts of TBI, particularly PTSS, depressive symptoms, and emotional dysregulation, remain underexplored in this context. Research has shown that these psychological sequelae often co-occur and significantly influence the rehabilitation outcomes of TBI survivors. Yet their prevalence, interrelationships, and role in recovery are not well understood within the Malaysian population.[10,15,20]

This study examines the prevalence and interrelationships of PTSS, depressive symptoms, and emotional dysregulation among TBI survivors in Malaysia. By addressing these psychological factors, this research aims to provide empirical data to inform the development of more comprehensive rehabilitation protocols that address both the physical and psychological needs of TBI survivors.[15,25,26]

MATERIALS AND METHODS

This quantitative cross-sectional study examined the prevalence and interrelationship of PTSS, depressive symptoms, and emotional regulation difficulties among individuals with self-reported TBI. Data were collected through an online survey disseminated via social media (e.g., WhatsApp, Facebook, and Instagram). Participants accessed the survey using QR codes or links. Participants aged 18 to 65 years with a self-reported history of TBI caused by external mechanical forces were included. Non-traumatic causes (e.g., stroke, tumours, or neurodegenerative diseases) were excluded. Eligibility was confirmed through a screening question defining TBI, and participants were required to understand English or Malay.

Purposive sampling was used in this study to specifically recruit individuals with self-reported histories of TBI who may be experiencing psychological symptoms such as PTSD, depression, and emotional regulation difficulties. This approach was necessary to ensure the sample included individuals with direct experience of TBI, which is critical to addressing the research questions. However, as with any purposive sampling method, this approach may introduce selection bias as it relies on participants' self-selection and may exclude individuals who are less engaged with TBI-related resources or support groups. This limitation should be considered when generalizing the findings to the broader TBI population. The sample size was determined using G*Power 3.1.9.4 to achieve a minimum of 139 participants, adjusted for a 25% attrition rate.[27]

The study employed three standardized assessment tools: (1) The Post-Traumatic Stress Disorder Checklist for DSM-5 (PCL-5) was used to assess post-traumatic stress symptoms. The PCL-5 is a 20-item self-report measure developed in accordance with DSM-5 diagnostic criteria and has demonstrated strong psychometric properties. A cutoff score of ≥33 was used to indicate probable PTSD, based on the validation evidence in Malaysian samples. Higher scores reflect greater severity of post-traumatic stress symptoms.[28] (2) the Patient Health Questionnaire (PHQ-9) to measure depressive symptoms. A score of ≥10 indicates moderate to severe depression.[29] This threshold has been validated in clinical and community samples to effectively identify individuals with clinically significant depressive symptoms. (3) the Emotion Regulation Questionnaire (ERQ) to assess the use of cognitive reappraisal and expressive suppression as emotional regulation strategies, categorized into low, medium, and high levels.

Data were collected online to maintain participant confidentiality, with all participants providing written informed consent. There was no time frame imposed between the occurrence of TBI and participation, allowing for the capture of ongoing psychological impacts.

Spearman's rank-order correlation was employed to examine relationships among PTSS, depressive symptoms, and emotional regulation, given the non-normal distribution of the data, as assessed by the Shapiro-Wilk test ($p<0.05$). Effect sizes were interpreted using conventional benchmarks (small =0.1, medium =0.3, large =0.5) to evaluate the strength of associations.

RESULTS

A total of 150 participants were included in the study, with an equal distribution of males (n=75) and females (n=75), and a mean age of 33.5 years (SD=8.6). The majority of participants were Malays (n=95). The highest educational qualifications among participants were SPM (n=40), Diploma (n=42), and bachelor's

degree (n=41). Most participants were employed full-time (n=106), followed by part-time workers (n=17) and the unemployed (n=27). The majority experienced a single episode of TBI (n=129), followed by recurrent episodes (n=18) and multiple episodes (n=3). The main cause of the participants' initial injury

was a motor vehicle accident (n=80), followed by a fall (n=30), a physical assault (n=14), a sports injury (n=14), and a work injury (n=6). The demographic information of the participants is presented in Table I.

Table I: Demographic Characteristics of Participants

Characteristic	Frequency (n)	Percentage (%)
Gender		
Male	75	50.0
Female	75	50.0
Race		
Malay	95	63.3
Chinese	37	24.7
Indian	9	6.0
Others	9	6.0
Education Level		
Bachelor's Degree	41	27.3
Diploma	42	28.0
Sijil Pelajaran Malaysia (SPM)	40	26.7
Foundation	14	9.3
Master's Degree	11	7.3
PhD	1	0.7
Others	1	0.7
Employment Status		
Full-time Employed	106	70.7
Part-time Employed	17	11.3
Unemployed	27	18.0
Frequency of TBI		
Multiple TBIs (>3)	3	2.0
Recurrent TBIs (2-3)	18	12.0
Single Incident	129	86.0
Cause of Initial TBI		
Motor Vehicle Accident	80	53.3
Fall-related Injury	30	20.0
Physical Assault	14	9.3
Sports-related Injury	14	9.3
Workplace Injury	6	4.0
Others	6	4.0

Table II shows the distribution of respondents according to levels of post-traumatic stress symptoms (PTSS), depressive symptoms, and emotional regulation difficulties. A total of 150 participants with traumatic brain injury (TBI) were included in the study. Of these, 80.7% (n=121) met the clinical threshold for PTSD as indicated by PCL-5 scores of ≥33, while 19.3% (n=29) did not meet the cutoff score. The 95% confidence interval for the proportion of participants meeting PTSD criteria is 74.52% to 86.88%, suggesting that the true population proportion is likely to fall within this range. For depressive symptoms, most participants,

43.3% (n=65), reported moderately severe symptoms (PHQ-9 scores ≥15), followed by 26.7% (n=40) with moderate symptoms, 13.3% (n=20) with severe symptoms, and 8.0% (n=12) with none or minimal symptoms.

For emotional regulation, cognitive reappraisal (ERQ_CR) scores showed that 42.7% (n=64) of participants had medium levels, 32.0% (n=48) had low levels, and 25.3% (n=38) had high levels. For expressive suppression (ERQ_ES), the majority of participants were in the medium range (48.0%; n=72), followed by 26.0% (n=39) with low levels and 26.0% (n=39) with high levels.

Table II: Levels of Post-Traumatic Stress Symptoms (PTSS), Depressive Symptoms, and Emotional Regulation Difficulties of Participants

Characteristic	Frequency (n)	Percentage (%)
Post-Traumatic Stress Symptoms (PTSS)		
Meets PTSD Diagnosis (≥33)	121	80.7
Does Not Meet PTSD Diagnosis (<33)	29	19.3
Depressive Symptoms		
None/Minimal	12	8.0
Mild	13	8.7
Moderate	40	26.7
Moderately Severe	65	43.3
Severe	20	13.3
Emotional Regulation (Cognitive Reappraisal)		
Low (≤24)	48	32.0
Medium (25-31)	64	42.7
High (≥32)	38	25.3
Emotional Regulation (Expressive Suppression)		
Low (≤11)	39	26.0
Medium (12-16)	72	48.0
High (≥17)	39	26.0

Table III presents the relationship between post-traumatic stress symptoms (PTSS) and depressive symptoms, as measured by the PHQ-9. A strong positive correlation was observed between PTSS and depressive symptoms (Spearman's ϱ=0.728, p<0.001), indicating that individuals with higher PTSS scores were significantly more likely to report more severe depressive symptoms.

Table III: Correlation Between Post-Traumatic Stress Symptoms (PTSS) and Depressive Symptoms (PHQ-9)

Variable	Spearman's ϱ	p-value
Post-Traumatic Stress Symptoms (PTSS)	1.000	-
Depressive Symptoms (PHQ-9)	0.728	< 0.001

Table IV shows the correlation between emotional regulation difficulties and the severity of post-traumatic stress symptoms. Cognitive reappraisal (ERQ_CR) showed a moderate positive correlation with PTSS (Spearman's ϱ=0.253, p=0.002), suggesting that individuals who engage more frequently in cognitive reappraisal may also report higher levels of PTSS. On the other hand, expressive suppression (ERQ_ES)

showed a strong positive correlation with PTSS (Spearman's ϱ=0.532, p<0.001), indicating that greater reliance on emotional suppression is associated with more severe PTSS.

Table 4: Correlation Between Emotional Regulation Difficulties and Post-Traumatic Stress Symptoms (PTSS)

Variable	Spearman's ϱ	p-value
Cognitive Reappraisal (ERQ_CR)	0.253	0.002
Expressive Suppression (ERQ_ES)	0.532	< 0.001
Post-Traumatic Stress Symptoms (PTSS)		

DISCUSSION

The study found high prevalence rates of PTSS, depressive symptoms, and emotional regulation difficulties among individuals with TBI. These results offer important insights into the psychological burden experienced by this population. Furthermore, PTSS was strongly associated with expressive suppression, and higher PTSS scores corresponded with more severe depressive symptoms.

Prevalence of PTSS, depressive symptoms and emotional regulation difficulties

The prevalence of PTSD observed in this study (80.7%) is substantially higher than pooled estimates reported among civilian populations with TBI. Previous evidence suggests that the overall prevalence of PTSD among individuals with TBI is approximately 27%, compared with 11% among those without TBI. Even when considering civilian samples alone, where PTSD prevalence following TBI has been reported at approximately 16%, the prevalence identified in the present study remains markedly elevated.[15] This discrepancy may be attributed to the nature of the online recruitment method, whereby individuals experiencing psychological distress may have been more likely to participate. Such recruitment may introduce sampling bias, as individuals who are more engaged with or concerned about their condition could be overrepresented, thereby inflating the observed prevalence. In addition, reliance on self-reported TBI diagnoses may contribute to misclassification bias. Consequently, the prevalence of PTSD in the broader civilian TBI population may be lower than that observed in the present study.[1]

While the relationship between injury severity and depressive symptoms was not directly analysed in this study, it is likely that more severe TBIs may be associated with more significant depressive symptoms. Previous literature has consistently found that individuals with moderate and severe TBI are at increased risk for depression.[30] Therefore, the elevated prevalence of PTSD observed here may primarily reflect the impact of a single TBI event rather than the cumulative effects of multiple injuries. The elevated PTSD prevalence in this study reinforces the importance of early intervention even for a patient with a single episode of injury that addresses both the physical and psychological dimensions of TBI recovery. However, future research should examine the impact of injury severity on mental health outcomes to better understand these associations.

The distribution of depressive symptom severity revealed that 43.3% of participants reported moderately severe symptoms, 26.7% reported moderate symptoms, and 13.3% exhibited severe symptoms. These findings align with previous studies reporting a high prevalence of depression following TBI, particularly in individuals with moderate-to-severe injuries.[31,32] For example, a previous study observed a 33.7% rate of depression one year post-TBI, with severity directly correlated to the extent of brain injury.[32] Although the

current study did examine the relationship between injury severity and depressive symptoms, the findings highlight the substantial emotional burden faced by individuals with TBI. Furthermore, a previous study reported that individuals with TBI are nearly twice as likely to develop depressive symptoms compared to those without TBI.[33] This result supports the elevated depression rates observed in this study. Psychosocial factors such as reduced functioning and social isolation, although not measured here, may further exacerbate depressive symptoms[34,35]. Collectively, these findings underscore the importance of integrated treatment approaches addressing both physical injury and psychosocial factors to improve mental health outcomes in TBI patients.

The study revealed that emotional regulation difficulties, measured through cognitive reappraisal (ERQ_CR) and expressive suppression (ERQ_ES), were prevalent among participants with TBI. Approximately 42.7% of participants scored in the medium range for cognitive reappraisal, while 48.0% scored in the medium range for expressive suppression. These findings are consistent with evidence that TBI can impair regions involved in emotional processing, such as the prefrontal cortex and amygdala.[20,36] These impairments may underlie challenges in recognizing and managing negative emotions such as anger and fear, as observed in a previous study.[37] This emotional dysregulation may be related to maladaptive emotional responses, such as expressive suppression, which is commonly used to manage intense emotions but may exacerbate psychological distress in TBI patients.[18]

In Malaysia and other Asian cultures, emotion suppression is often seen as a normative response to emotional challenges, especially in more collectivist societies. In these cultures, there is often an emphasis on maintaining social harmony and avoiding the outward expression of distress, which can lead individuals to suppress their emotions as a coping mechanism. This cultural tendency may exacerbate the emotional regulation difficulties faced by individuals with TBI, as these individuals may be more likely to rely on suppression, which can worsen the severity of PTSS and depressive symptoms. The role of cultural values in shaping emotional regulation strategies, such as emotion suppression, should therefore be considered in both the assessment and treatment of TBI patients in Malaysia.[39]

Relationship Between Emotional Regulation Difficulties and PTSS

PTSS severity was positively associated with both cognitive reappraisal and expressive suppression. The positive correlation between cognitive reappraisal and PTSS diverges from traditional literature, which typically positions cognitive reappraisal as an adaptive emotion regulation strategy.[39] However, the findings align with recent studies on acquired brain injury (ABI), where individuals with TBI struggle to implement effective reappraisal strategies due to cognitive deficits.[40] This suggests that the maladaptive use of cognitive reappraisal due to cognitive impairments resulting from TBI may actually exacerbate emotional distress rather than providing adaptive coping mechanisms. Cognitive reappraisal involves reinterpreting a stressful situation to reduce its emotional impact, but TBI often impairs cognitive functions such as attention, memory, and executive control, making it difficult for individuals to effectively reframe their thoughts. As a result, individuals with TBI may fail to use reappraisal effectively, potentially increasing their emotional distress and contributing to the severity of PTSS symptoms.

In contrast, expressive suppression was found to be strongly correlated with PTSS, which supports prior research suggesting that suppressing emotional expressions can exacerbate PTSD symptoms.[41,42] The study's findings highlight the importance of addressing both cognitive reappraisal and expressive suppression in interventions aimed at reducing PTSD severity in TBI patients.

Correlation Between PTSS and Depressive Symptoms

PTSS and depressive symptoms were strongly correlated, and this is consistent with evidence that these conditions frequently co-occur after TBI.[12,16] The neurological impairments resulting from TBI, which affect brain regions responsible for emotional processing, such as the hippocampus, amygdala, and prefrontal cortex, contribute to the severity of both PTSS and depressive symptoms.[4] To illustrate, impairment of the hippocampus, which plays a key role in memory consolidation and regulation of the stress response, may be related to difficulties in distinguishing between safe and threatening stimuli, thereby intensifying re-experiencing symptoms and mood disturbances. Dysfunction in the amygdala, responsible for processing emotional salience and fear, can cause heightened emotional reactivity and exaggerated fear responses, worsening hyperarousal and anxiety symptoms commonly seen in PTSD and depression. Damage to the prefrontal cortex, which is involved in executive function and emotional regulation, can reduce the ability to control negative emotions and intrusive memories, further linking the severity of PTSS and depressive symptoms in TBI.[25]

The findings underscore the need for integrated treatment approaches that address both PTSD and depression simultaneously, as treating these conditions in isolation may limit the effectiveness of interventions. Cognitive-behavioral therapy (CBT), including trauma-focused CBT, has been shown to be effective in managing co-occurring PTSD and depression,[42] and should be incorporated into clinical practice.[43]

Implications for Clinical Practice

The findings of this study have important implications for clinical practice, particularly in the rehabilitation of patients with TBI. The high prevalence of PTSS, depressive symptoms, and emotional regulation difficulties indicates a potential benefit of comprehensive and integrated care models that address the

cognitive, emotional, and behavioural dimensions of TBI recovery. This includes early psychological assessment and intervention, as well as integrating emotional regulation strategies into treatment plans.[30,44]

Limitations and Recommendations for Future Research

This study has several limitations. The relatively small and homogeneous sample limits the generalizability of the findings, and future studies should recruit larger and more diverse populations. The cross-sectional design limits causal interpretation, underscoring the need for longitudinal research. Another limitation is the reliance on self-report measures, which may introduce bias. Future studies should incorporate multi-method assessment approaches to improve diagnostic accuracy. The emotional regulation assessment should be expanded to include other strategies, such as rumination and emotional avoidance. Comorbid factors such as chronic pain and sleep disturbances should also be explored for their impact on psychological outcomes.

CONCLUSION

This study highlights the high prevalence of PTSS, depressive symptoms, and emotional regulation difficulties in individuals with TBI in Malaysia. The significant associations between expressive suppression and PTSD severity indicate that maladaptive emotional regulation strategies may exacerbate psychological symptoms. The strong association between PTSD and depression supports consideration of integrated treatment approaches that address both conditions.

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper.

INSTITUTIONAL REVIEW BOARD (ETHICS COMMITTEE)

The study protocol was approved by the Jawatankuasa Etika Penyelidikan Manusia Universiti Sains Malaysia (JEPeM-USM) under the study code USM/JEPeM/KK/24090851.

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REFERENCES

1. Babiloni AH, Exposto FG, Bouferguene Y, et al. Temporomandibular disorders in traumatic brain injury patients: A chronic pain condition requiring further attention. Pain Med. 2020;21(12):3260–2. doi:10.1093/pm/pnaa234.
2. Maas AIR, Menon DK, Manley GT, et al. Traumatic brain injury: Progress and challenges in prevention, clinical care, and research. Lancet Neurol. 2022;21(11):1004–60. doi:10.1016/s1474-4422(22)00309-x.
3. Dewan MC, Rattani A, Gupta S, et al. Estimating the global incidence of traumatic brain injury. J Neurosurg. 2018;130(4):1080–97. doi:10.3171/2017.10.jns17352.
4. Teh J, Mazlan M, Danaee M, et al. Outcome of 1939 traumatic brain injury patients from road traffic accidents: Findings from specialist medical reports in a low to middle-income country (LMIC). PLoS ONE. 2023;18(9):e0284484. doi:10.1371/journal.pone.0284484.
5. Jamaluddin S, Wahab M, Wahab M, et al. National trauma database January 2009 to December 2009 – Fourth report. Available from: http://www.acrm.org.my/ntrd/
6. Arulsamy A, Shaikh MF. Current status of traumatic brain injury research in Malaysia: A systematic review. Neurosci Res Notes. 2020;3(4):1–21. doi:10.31117/neuroscirn.v3i4.52.
7. Howlett JR, Nelson LD, Stein MB. Mental health consequences of traumatic brain injury. *Biol Psychiatry*. 2022;91(5):413-420. doi:10.1016/j.biopsych.2021.09.024.

8. Torregrossa W, Raciti L, Rifici C, et al. Behavioral and psychiatric symptoms in patients with severe traumatic brain injury: A comprehensive overview. Biomedicines. 2023;11(5):1449. doi:10.3390/biomedicines11051449.
9. Fisher ER, Montroy JJ, Duque G, et al. Post-concussion and post-traumatic stress symptoms after pediatric traumatic brain injury: Shared vulnerability factors? J Neurotrauma. 2021;38(18):2600–9. doi:10.1089/neu.2020.7541.
10. Iljazi A, Ashina H, Al-Khazali HM, et al. Post-traumatic stress disorder after traumatic brain injury—a systematic review and meta-analysis. Neurol Sci. 2020;41(10):2737–46. doi:10.1007/s10072-020-04458-7.
11. Barak S, Gerner M, Berant E, et al. Evolution and factors associated with pediatric post-traumatic stress disorder 1 year after mild traumatic brain injury: A prospective, longitudinal study. Int J Rehabil Res. 2025;48(1):40–7. doi:10.1097/MRR.0000000000000655.
12. Shi S, Almklov E, Afari N, Pittman JO. Symptoms of major depressive disorder and post-traumatic stress disorder in veterans with mild traumatic brain injury: A network analysis. PLoS ONE. 2023;18(5):e0283101. doi:10.1371/journal.pone.0283101.
13. Van Der Vlegel M, Polinder S, Mikolic A, et al. The association of post-concussion and post-traumatic stress disorder symptoms with health-related quality of life, health care use and return-to-work after mild traumatic brain injury. J Clin Med. 2021;10(11):2473. doi:10.3390/jcm10112473.
14. Van Praag DL, Cnossen MC, Polinder S, et al. Post-traumatic stress disorder after civilian traumatic brain injury: A systematic review and meta-analysis of prevalence rates. J Neurotrauma. 2019;36(23):3220–32. doi:10.1089/neu.2018.5759.
15. Loignon A, Ouellet M, Belleville G. A systematic review and meta-analysis on PTSD following TBI among military/veteran and civilian populations. J Head Trauma Rehabil. 2019;35(1):E21–E35. doi:10.1097/htr.0000000000000514.
16. Mikolić A, Van Klaveren D, Jost M, et al. Prognostic models for depression and post-traumatic stress disorder symptoms following traumatic brain injury: A CENTER-TBI study. BMJ Ment Health. 2025;28(1):e301181. doi:10.1136/bmjment-2024-301181.
17. Simonovic M, Nedovic B, Radisavljevic M, et al. The co-occurrence of post-traumatic stress disorder and depression in individuals with and without traumatic brain injury: A comprehensive investigation. Medicina. 2023;59(8):1467. doi:10.3390/medicina59081467.
18. Rezaei S, Jafroudi M. Emotion dysregulation following traumatic brain injury: A systematic review. Iran J Neurosurg. 2023;9(0):20. doi:10.32598/irjns.9.20.
19. Sultana T, Hasan MA, Kang X, et al. Neural mechanisms of emotional health in traumatic brain injury patients undergoing rTMS treatment. Mol Psychiatry. 2023;28(12):5150–8. doi:10.1038/s41380-023-02159-z.
20. Weis CN, Webb EK, deRoon-Cassini TA, et al. Emotion dysregulation following trauma: Shared neurocircuitry of traumatic brain injury and trauma-related psychiatric disorders. Biol Psychiatry. 2021;91(5):470–7. doi:10.1016/j.biopsych.2021.07.023.
21. Filippone A, Cucinotta L, Bova V, et al. Inhibition of LRRK2 attenuates depression-related symptoms in mice with moderate traumatic brain injury. Cells. 2023;12(7):1040. doi:10.3390/cells12071040.

22. Ruiz-Gutiérrez J, Arias-Sánchez S, Martín-Monzón I. Neuropsychology of executive functions in patients with focal lesion in the prefrontal cortex: a systematic review. Brain Cogn. 2020; 146:105633. doi: 10.1016/j.bandc.2020.105633.
23. Šimić G, Tkalčić M, Vukić V, et al. Understanding emotions: Origins and roles of the amygdala. Biomolecules. 2021;11(6):823. doi:10.3390/biom11060823.
24. Sahel DK, Kaira M, Raj K, et al. Mitochondrial dysfunctioning and neuroinflammation: Recent highlights on the possible mechanisms involved in traumatic brain injury. Neurosci Lett. 2019;710:134347. doi:10.1016/j.neulet.2019.134347.
25. Carmichael J, Ponsford J, Gould KR, et al. Characterizing depression after traumatic brain injury using a symptom-oriented approach. J Affect Disord. 2023;345:455–66. doi:10.1016/j.jad.2023.10.130.
26. Vasterling JJ, Jacob SN, Rasmusson A. Traumatic brain injury and posttraumatic stress disorder: conceptual, diagnostic, and therapeutic considerations in the context of co-occurrence. J Neuropsychiatry Clin Neurosci. 2018;30(2):91–100. doi: 10.1176/appi.neuropsych.17090180.
27. Capizzi A, Woo J, Verduzco-Gutierrez M. Traumatic brain injury. Med Clin North Am. 2020;104(2):213–38. doi:10.1016/j.mcna.2019.11.001.
28. Guskiewicz KM, Marshall SW, Bailes J, et al. Recurrent concussion and risk of depression in retired professional football players. Med Sci Sports Exerc. 2007;39(6):903–9. doi:10.1249/mss.0b013e3180383da5.
29. Kang H. Sample size determination and power analysis using the G*Power software. J Educ Eval Health Prof. 2021;18:17. doi:10.3352/jeehp.2021.18.17.
30. Ghazali SR, Chen YY. Reliability, concurrent validity, and cutoff score of PTSD Checklist (PCL-5) for the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition among Malaysian adolescents. Traumatology. 2018;24(4):280–7. doi:10.1037/trm0000156.
31. Smith NIJ, Hogarth L, Tonks J, Corrigan JD, Gilmour S, Williams WH. Co-occurrence of traumatic brain injury and post-traumatic stress disorder in a national sample of UK police officers: Impact on social well-being and employment outcomes. J Head Trauma Rehabil. 2025;40(4):247–57. doi:10.1097/HTR.0000000000001041.
32. Choi EB, Jang SH. Degeneration of core neural tracts for emotional regulation in a patient with traumatic brain injury. Medicine. 2021;100(4):e24319. doi:10.1097/md. 0000000000024319.
33. Looi MC, Idris Z, Kumaran T, et al. A study of 309 patients and at one-year follow-up for depression after traumatic brain injury. J Neurotrauma. 2022;40(1–2):94–101. doi:10.1089/neu.2022.0031.
34. Dehbozorgi M, Maghsoudi MR, Rajai S, et al. Depression after traumatic brain injury: A systematic review and meta-analysis. Am J Emerg Med. 2024;86:21–9. doi:10.1016/j.ajem.2024.08.039.
35. Ali MM, Hoesni SM, Rosharudin NA, et al. Translation and validation of the Malay version of the Emotion Regulation Questionnaire for Children and Adolescents (ERQ-CA). Int J Environ Res Public Health. 2022;19(18):11399. doi:10.3390/ijerph191811399.
36. Choi Y, Kim EY, Sun J, et al. Incidence of depression after traumatic brain injury: A nationwide longitudinal study of 2.2 million adults. J Neurotrauma. 2021;39(5–6):390–7. doi:10.1089/neu.2021.0111.
37. Tull MT, Vidaña AG, Betts JE. Emotion regulation difficulties in PTSD. In: Elsevier eBooks. 2020:295–310. doi:10.1016/b978-0-12-816022-0.00010-7.

38. Murphy JM, Bennett JM, De La Piedad García X, et al. Emotion recognition and traumatic brain injury: A systematic review and meta-analysis. Neuropsychol Rev. 2021;32(3):520–36. doi:10.1007/s11065-021-09510-7.
39. Larionow P, Ocalewski J, Mudło-Głagolska K, et al. The clinical significance of cognitive reappraisal and expressive suppression across positive and negative emotions: Evidence on the Polish version of the Emotion Regulation Questionnaire – Positive/Negative (ERQ-PN). Front Psychiatry. 2025;16:1614234. doi:10.3389/fpsyt. 2025.1614234.
40. Rowlands L, Coetzer R, Turnbull O. This time it's personal: Reappraisal after acquired brain injury. Cogn Emot. 2020;35(2):305–23. doi:10.1080/02699931.2020.1839384.
41. Chen L, Wang Q, Xu T. Working memory function in patients with major depressive disorder: A narrative review. Clin Psychol Psychother. 2022;30(2):281–93. doi:10.1002/cpp. 2811.
42. Tan L, Deady M, Bryant RA, et al. Adaptive and maladaptive cognitive-emotional strategies associated with PTSD in first responders. J Occup Environ Med. 2023;65(6):e372–e377. doi:10.1097/jom.0000000000002829.
43. Wilson L, Horton L, Kunzmann K, et al. Understanding the relationship between cognitive performance and function in daily life after traumatic brain injury. J Neurol Neurosurg Psychiatry. 2020;92(4):407–17. doi:10.1136/jnnp-2020-324492.
44. Pourjafari M, Mirshafiei F. Comparing the effectiveness of emotion-focused group therapy and cognitive behavioral therapy on suicidal ideation and emotional security of women with major depression. Int J Body Mind Cult. 2025;12(1):150–63. doi:10.61838/ijbmc.v12i1.725.