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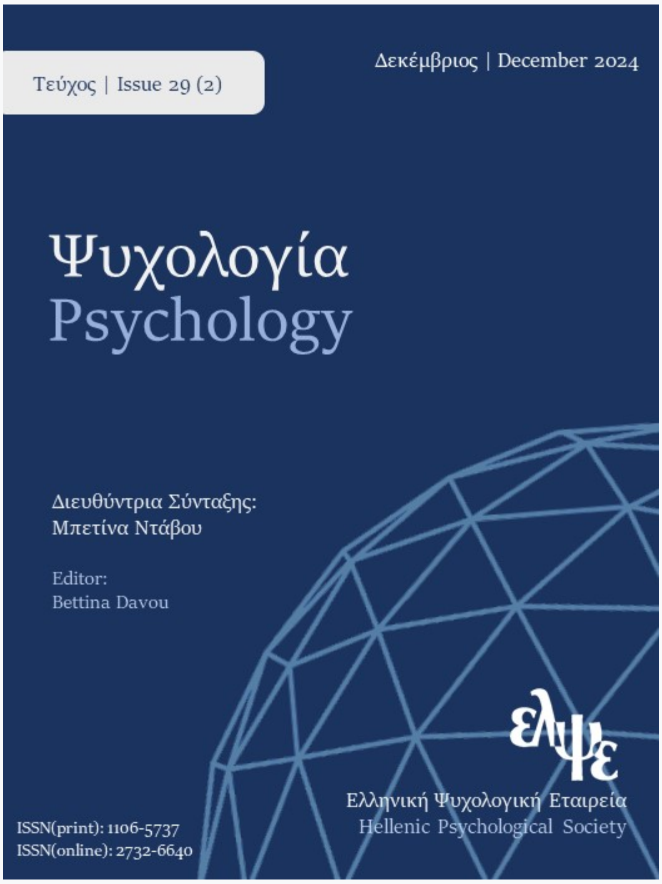

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ΕΜΠΕΙΡΙΚΗ ΕΡΓΑΣΙΑ | RESEARCH PAPER

Role of Neuropsychological Factors in Post Head Injury Symptoms of Complicated Mild-moderate Traumatic Brain Injury patients

Akanksha CHAURASIYA[1], Jay Kumar RANJAN[2], Nityanand PANDEY[3], Hari Shanker ASTHANA[4]

[1] Department of Psychology, Vasanta College for Women, Banaras Hindu University
[2] Department of Psychological Sciences, Central University of South Bihar, Gaya
[3] Department of Neurosurgery, Institute of Medical Science, Banaras Hindu University
[4] Department of Psychology, Faculty of Social Science, Banaras Hindu University

KEYWORDS

Traumatic brain injury
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CORRESPONDENCE

Jay Kumar Ranjan
Professor, Department of Psychological Sciences,
Central University of South Bihar,
Gaya, India
jaykumarranjan@gmail.com

ABSTRACT

Traumatic brain injury (TBI) is a significant public health issue. The prevalence of post-head injury symptoms is well documented. However, only a few studies have examined its predictors, specifically the role of the neurocognitive and affective components in post-head injury symptoms. To examine the predictive role of neurocognitive and affective factors in post-head injury symptoms of complicated mild to moderate TBI patients. Thirty-nine patients with a GCS score of 9 to 15 and evidence of radiological intracranial abnormality were recruited for the study. All patients were assessed with neurocognitive measures such as the Stroop test for inhibitory control, the AIIMS memory scale for memory, and the Trail Making Test (TMT) for attention. The psychological distress of patients was assessed with the Hospital Anxiety Depression Scale (HADS), and post-head injury symptoms were assessed with the Rivermead Post Concussive Symptom Questionnaire (RPCSQ). Logistic regression analyses were conducted with predictors as neurocognitive measures and HADS scores and criterion variables as subjectively reported post-head injury symptoms on RPCSQ. Psychological distress and attention score significantly predict the presence of post-head injury cognitive symptoms in participants with complicated mild to moderate TBI ($p<.05$). In contrast, severity of injury significantly predicted the presence of post-head injury symptoms in physical/ somatic domain ($p<.05$). Furthermore, psychological distress and memory scores significantly predict presence of affective symptoms in participants with complicated mild-moderate TBI ($p<.05$). These findings suggest the need of addressing psychological distress along with neurocognitive impairment as a crucial component in neurorehabilitation for participants with complicated mild-moderate TBI.

Introduction

Traumatic Brain Injury (TBI) and its sequelae in TBI survivors remain a significant public health concern (Burton, 2016). An epidemiological study indicates that nearly 1.5 to 2 million people in India suffer from brain injuries each year; among them, 1 million succumbed to death, and almost 1 million who survived require extensive rehabilitation services (Gururaj, 2002). Further, an estimation indicates that annually, about 1.5 million Americans suffer from TBI, and approximately 230,000 are hospitalized (Matney et al., 2022). In the context of Europe, various country-level studies have indicated that incidence rates ranged from 47.3 per 100,000 to 694

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per 100,000 population per year (Brazinova et al., 2021). Neuropsychological rehabilitation for TBI survivors mainly aims to facilitate the recovery of neurocognitive functioning, post-head injury symptoms, emotional problems, and socio-behavioural functioning (Barman et al., 2016). However, there is a lack of knowledge about the factors of post-head injury symptoms in TBI patients, which makes the rehabilitation efforts less efficient.

TBI is categorized as mild, moderate, and severe (Teasdale & Jennett, 1974). Mild TBI includes confusion or disorientation, loss of consciousness for 30 minutes or less, post-traumatic amnesia for less than 24 hours, and other transient neurological abnormalities and Glasgow Coma Scale score of 13–15 within 30 minutes post-injury or upon presentation for healthcare (Teasdale & Jennett, 1974). Mild TBI is further classified as complicated and uncomplicated mild TBI (Williams et al., 1990). A trauma-induced brain abnormality on Computerized Tomography (CT) scan or Magnetic Resonance Imaging (MRI) is present in complicated mild TBI. In contrast, in uncomplicated mild TBI, no brain lesions are reported in CT or MRI (Williams et al., 1990). The patients with moderate TBI have a loss of consciousness for 30 minutes to 24 hours, post-traumatic amnesia for 1 to 7 days, and a Glasgow Coma Scale score of 9–12 at the time of admission (Blyth & Bazarian, 2010). Several researchers have advocated the dose-response relationship between TBI severity and neurocognitive performances (Rohling et al., 2003). Studies have indicated differences in outcomes between Complicated Mild TBI and Moderate TBI patients (Kashluba et al., 2008; Lange et al., 2012). However, studies have also found no significant differences in simple neuropsychological functional outcomes between the complicated mild and moderate TBI groups (Chaurasiya et al., 2021b; Ghawami et al., 2017; Lange et al., 2012; Williams et al., 1990). This implies that several other factors besides severity also play a role in post-TBI outcomes.

Psychologists agree that recovery in rehabilitation for TBI patients occurs through autoregulation and homeostasis and facilitates the patients to reintegrate into premorbid personal and social functioning (Shoulsen et al., 2012). After TBI, neuronal plasticity occurs and aids in the recovery of neuropsychological functioning to some extent but leaves the patients with some residual symptoms (Su et al., 2016). The constellation of these cognitive (e.g., memory problems, concentration difficulty, and slow speed of thought processes), emotional (e.g., bad temper, irritation, depression, and impatience), and somatic (e.g., headache, vomiting, poor sleep, dizziness, fatigue, nausea, light sensitivity, noise sensitivity, and visual problems) symptoms are often termed as post head injury symptoms or post-concussive symptoms (King et al., 1995). These post-head injury symptoms significantly impact patients in neurocognitive functioning and occupational, social, emotional, and personal domains. Persistent post-head injury symptoms negatively affect rehabilitation and hinder the recovery process (King et al., 1999). Therefore, a better understanding of factors that play a significant role in persistent post-head injury symptoms is of utmost importance in planning rehabilitation strategies.

Researchers have studied the factors associated with post-TBI sequelae and found differential roles of cognitive and emotional factors in head injury symptoms post-TBI (Bertisch et al., 2013; Gunstad & Suhr, 2004; Himanen et al., 2009; Meares et al., 2006; Schiehser et al., 2011). Much of the literature states that cognitive factors play a major role in estimating post-head injury symptoms. Patients with TBI have difficulty performing neurocognitive tasks, which results in underrating cognitive functioning, which further exaggerates cognitive symptoms and complaints in patients (Gould et al., 2014). On the other hand, various studies have found emotional factors as a significant predictor in post-head injury symptoms (Gunstad & Suhr, 2004; Meares et al., 2006; Schiehser et al., 2011) as emotional distress is strongly related to cognitive complaints after TBI (Stulemeijer et al., 2007). On this line, studies have also reported that TBI patients with depressive symptoms reported more post-head injury symptoms (Himanen et al., 2009). Thus, there are sufficient shreds of evidence available regarding the role of neurocognitive and affective components in post-head injury symptoms among patients with mild and severe TBI. Still, research is scarce on complicated mild to moderate TBI patients.

A dearth of studies has also addressed the post-TBI outcome and symptoms in the Indian scenario (Agrawal et al., 2016). A few studies conducted in the Indian context have emphasized neurocognitive functioning, but post-injury symptoms are neglected in this scenario (Chaurasiya et al., 2021a; Chaurasiya et al., 2021b). A more precise understanding of the post-TBI symptomatic outcome and the role of cognitive and emotional factors in symptoms is essential. This will be imperative for clinicians to plan an effective treatment and determine long-term prognosis in these patients.

The present study aimed to assess the role of neurocognitive impairments and psychological distress on post-head injury symptoms in patients with complicated mild and moderate TBI. In light of previous literature (Bertisch et al., 2013; Gunstad & Suhr, 2004; Stulemeijer et al., 2007; Himanen et al., 2009; Meares et al., 2006; Schiehser et al., 2011), this was hypothesized that severity, cognitive functioning, and psychological distress would significantly predict the post head injury symptoms in participants with complicated mild to moderate TBI.

Method

Participants

The present study was conducted in Out Patient Department of Neurosurgery ward of a level 1 trauma centre. This trauma centre is a specialized medical centre offering advanced and immediate care for critical trauma cases and nearly 5000 brain injury patients annually, including subsidized treatment for those with lower economic status. The ethical committee of the Institute of Medical Sciences, Banaras Hindu University, approved the present study protocol. The group of participants comprised 39 patients with complicated mild-moderate TBI. The purposive sampling technique was used here because the study aimed to assess the predictive role of several factors in symptomatic complaints post-injury, specifically in participants with complicated mild to moderate TBI and frontal and temporal lesions in the brain. Participants having brain injury with a GCS score of 9 to 15 at the time of arrival, less than 24 hrs loss of consciousness, Post Traumatic Amnesia (PTA) of less than seven days, evidence of radiological intracranial abnormality in frontal or temporal area on CT scan or an MRI, and were able to read and comprehend Hindi language properly, were included in the study. Patients who scored below four on the digit span effort task, with major problems in communication, hearing, visualization, motor coordination or physical amputation after injury, previous psychiatric disorder, previous history of head trauma or injury, or current psychiatric disorder, were excluded from the study. A flowchart for the number of patients included in the present study is shown in Figure 1.

Eighty-six participants with complicated mild to moderate TBI admitted between December 2018 and May 2019 were identified for the study. Of those, 68 patients met the inclusion and exclusion criteria of the study; among them, only 46 patients came for the follow-up. Finally, only 39 TBI patients were included in the study, as seven patients had not completed or denied participation (Figure 1). The mean age of all the participants was approximately 29 years, and a large proportion of the participants were males (74.4%). Among all, 19 patients (48.7%) were single. Most of the participants have graduation as their academic qualification (48.7%).

Informed consent was obtained from patients and their caregivers before they entered the study. In the study, only participants who could read and comprehend properly were recruited; therefore, patients could provide written informed consent. Additionally, informed consent was obtained from their caregiver, who visited the trauma centre, to ensure appropriateness and adherence to ethical guidelines.

Measures

Patients were assessed using several neurocognitive, psychological distress, and post-head injury symptoms measures. Details of measures are given below:

Predictor variables

Stroop colour-word task. Stroop colour-word task measures the functioning of shifting perceptual set and response inhibition (Stuss & Benson, 1986), a component of executive functioning (Stroop, 1935). In the Colour-word Stroop test (Stroop, 1935), the subjects are required to name the colour of the word printed in the same colour (Stroop facilitation) and in different ink colours (Stroop interference, e.g., red printed in blue ink has to be read as blue). ***Outcome measures:*** Reaction Time has been measured to name the colour of the word when it is printed in the same colour (Stroop facilitation) and in a different ink colour (Stroop interference). The interference score was calculated by calculating the difference in reaction times between Stroop interference and Stroop facilitation conditions. The scores were compared with standard Indian population norm scores (Rao, Subbakrishna and Gopukumar, 2004).

AIIMS memory scale. This scale measures memory functioning (Gupta et al., 2000). The scale comprised 12 items that measure various types of memory, including remote and recent memory, recognition, immediate verbal recall, immediate memory for digits forward and backward, and verbal and non-verbal recall with homogenous and heterogeneous interference. This is a reliable and valid instrument to assess memory dysfunctions and is applicable in both psychiatric and neurological patients. AIIMS memory scale has been relatively satisfactory standardization on Indian patients and is widely used in diagnosis, assessment, and cognitive rehabilitation services (Nehra, Pershad and Chopra, 2016). ***Outcome measures:*** Overall Memory Functioning has been measured by a composite score derived from all the 12 items on the scale. The scores of individuals were then compared with standard norm scores and based on these norms, patients were categorized as problematic or non-problematic cases.

Trail Making Test (TMT). Trail Making Test (TMT) colour trial is used to assess visual search speed, scanning, and processing speed (Tombaugh, 2004). The test was adapted and validated in an Indian setting and included in the NIMHANS neuropsychological test (Rao, Subbakrishna and Gopukumar, 2004). TMT is a brief and reliable tool for predicting outcome functioning, and this helps to target the need for further intervention and rehabilitation following TBI (De Guise, 2016 . ***Outcome measures:*** The time taken to complete the trial was measured, and scores were compared with standardized norms for the Indian population to categorize patients into problematic and non-problematic cases (Rao, Subbakrishna and Gopukumar, 2004).

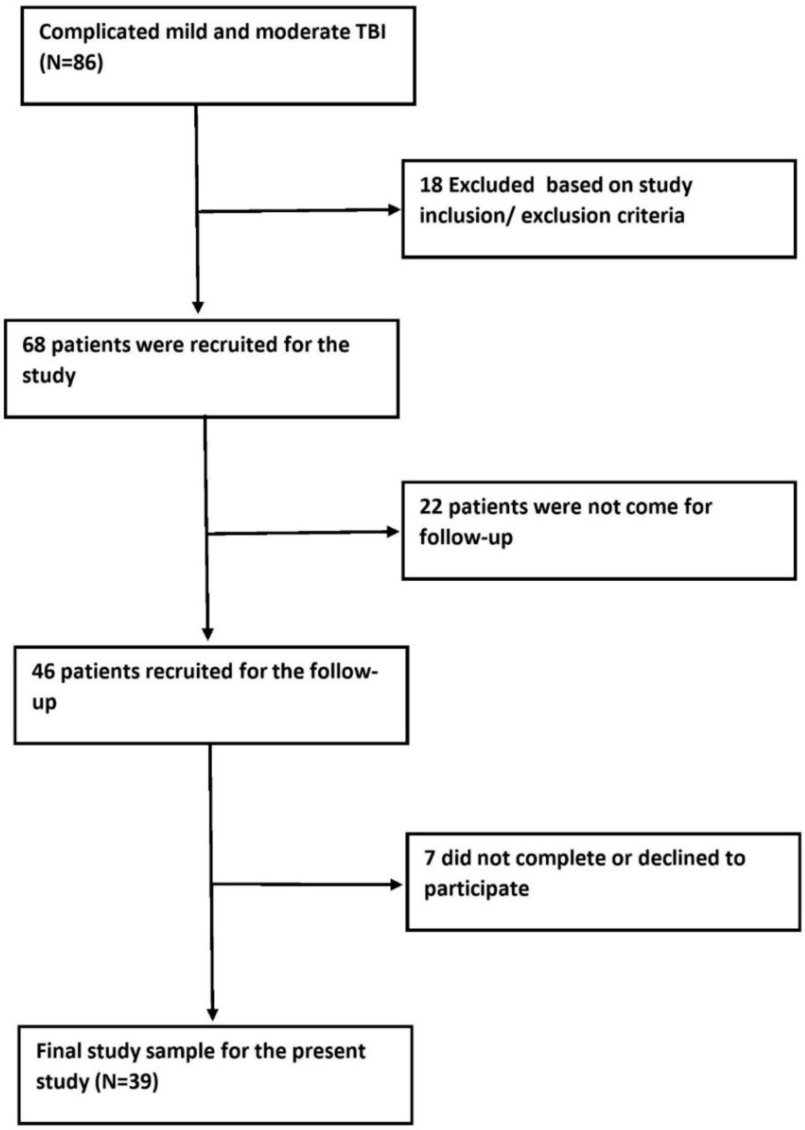
Hospital Anxiety Depression Scale (HADS): The HADS measures psychological distress, with a range of 0 (*not at all*) to 3 (*most of the time*) on two subscales, i.e., Anxiety subscale and Depression subscale (Zigmond & Snaith, 1983). A score of ≥8 on any domain indicates psychological distress in that domain. The Hindi version of the Hospital Anxiety and Depression Scale (HADS) has been validated on normal as well as TBI patients by the authors, which has good internal consistency (anxiety: α=.80, depression: α=.76) and satisfactory validity. ***Outcome measures:*** The Anxiety Subscale Score was derived by the sum of scores for anxiety-related items (range: 0 to 21). Similarly, Depression Subscale Scores were derived by the sum of scores for the depression-related items (range: 0 to 21). Patients with scores greater than or equal to 8 on either subscale indicate significant psychological distress, whereas patients with less than eight scores were considered a non-problematic case.

Outcome Variable

Rivermead Post Concussion Symptom Questionnaire (RPCSQ). This questionnaire has been used to assess the presence and severity of post-head injury symptoms (King et al., 1995). The RPCSQ comprised a list of 16 post-concussion symptoms with a range on a scale of 0 (absent) to 4 (severe problem). Ratings of ≥ 2 on any symptoms indicate the problem. A score of ≥ 2 on four or more items defines a case. For this study, the Hindi translation and validation of RPCSQ has been used, which was already done by the authors. The test has shown strong reliability (test-retest correlations: 0.74 to 0.90), internal consistency (Cronbach's alpha: around 0.90), and strong concurrent validity (0.62 to 0.82) of this measure. ***Outcome measures:*** The RPCSQ comprised a list of 16 post-concussion symptoms with a range on a scale of 0 (absent) to 4 (severe problem). Ratings greater than or equal to 2 on any symptoms indicate a problematic case. Patients with scores greater than or equal to 2 on four or more than four symptoms indicate a problematic case. These dichotomized categories have been entered into the logistic regression model.

As part of the assessment, patients have also completed the digit span task to evaluate effort during testing. Patients were classified as having "poor effort" when their score on the digit span task forward was below four, and these patients were excluded from the study.

Figure 1. *Flow Chart of patients recruitment for the study*



Procedure

The clinical and demographical details of the patients were recorded, and written informed consent was obtained from each participant. After that, neuropsychological tests, HADS and RPCSQ, were administered and scored according to the standardized procedure. The individual testing sessions ranged from 20 minutes to 30 minutes, with the rest of the 5 minutes between the two sessions. The entire test administration procedure took 60 minutes to 90 minutes. The assessments were conducted within a 6-month post-TBI epoch, ranging from 4.5 months to 7 months after the injury. Ethical guidelines recommended by the Helsinki Declaration were strictly adhered to during the data collection process.

Statistical Analysis

The data were analyzed using logistic regression, i.e., non-parametric statistics. To assess the factors that predict the post-head injury symptoms in participants with complicated mild-moderate TBI, neurocognitive (Stroop, TMT-A, and AIIMS) and psychological distress (HADS- anxiety and depression scores) were entered into the logistic regression model, as the predictors. The multicollinearity of factors was checked, and factors having a correlation of below 0.40 with other factors were selected. Three separate logistic regression models were assessed for the emotional, cognitive, and somatic subscales. These three domains of RPCSQ (cognitive, affective, and somatic) were dichotomized into problematic and non-problematic cases and entered as criterion variables in the model. The significance level was set to $p = 0.05$. All the statistical analysis was carried out with the SPSS, Version 20 (SPSS Inc., Chicago, IL, USA).

Results

Table 1 depicts the percentage of participants with complicated mild to moderate TBI having cognitive impairments and psychological distress after the injury based on cut-off values/criteria for TBI patients.

Table 1. *Neurocognitive and affective component profile of Complicated Mild and Moderate TBI patients*

Neurocognitive function	Impaired/ Problematic cases (N=39)	
	n	%
TMT-A	19	48.72%
Stroop	22	56.41%
AIIMS-MS	11	28.21%
HADS-A	19	48.72%
HADS-D	11	28.21%
Affective symptom	17	43.60%
Cognitive symptom	22	56.40%
Somatic symptom	12	30.80%

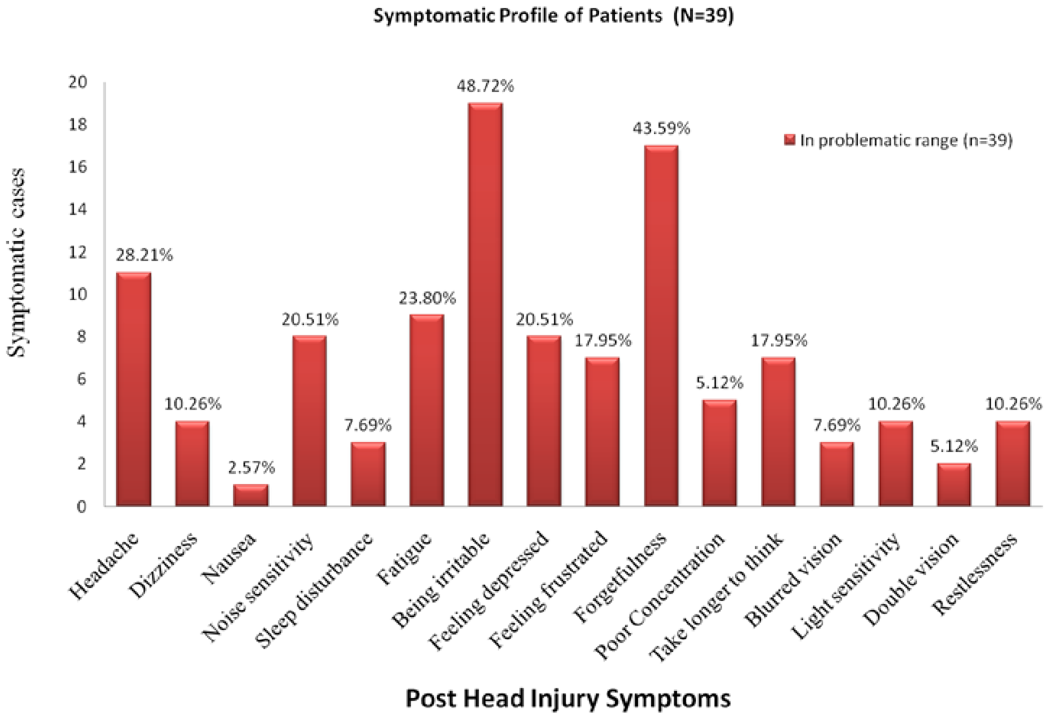
**Note.* TMT-A:Trail making test-part A, AIIMS-MS:AIIMS Memory scale, HADS-A: Hospital anxiety and depression scale-anxiety subscale, HADS-D: Hospital anxiety and depression scale-depression subscale

On the neurocognitive domain, most of the participants with complicated mild to moderate TBI have impaired performance on the DSST mental processing speed task (66.7%), followed by the Stroop task related to inhibitory control (56.4%) and TMT for attention (48.7%). In the affective domain, 9 (23.1%) and 11 (28.2%) patients were found with anxiety and depressive symptoms, respectively (table 1). The percentage of participants with problems in RPCSQ is presented in Figure 2.

Logistic regression analysis was used to examine the role of neurocognitive function, i.e., Stroop, TMT, and AIIMS memory scale and HADS (psychological distress) on post-head injury symptoms, i.e., somatic, affective, and cognitive symptomatic complaints. Three separate logistic regression models represented the predictive models for the different domains of head injury symptoms. A posteriori analysis was conducted to assess the goodness-of-fit for all three models, and they were found suitable according to the Hosmer and Lemeshow Test. Each one of the variable logits of the model was linearly related to the outcome variable, as the interaction was non-significant. The tolerance value of the variable was .231 to .641, and the VIF (Variance Inflation Factor) value was 1.57 to 4.34. Thus, the tolerance and VIF value indicate the absence of multicollinearity in the model. The Cook's distance value of data suggests no significant, influential effects on the model. The standardized residual values were found to be less than absolute 2, indicating non-significant residuals in present models.

The model reveals that TMT-A, anxiety and depression were found to be significant factors in predicting presence of post-head injury subjective complaints of cognitive problems in participants with complicated mild-moderate TBI. Patients with slow RT (Reaction Time) on TMT-A are 16.22 times more likely to complain about cognitive problems (p=.004). Similarly, patients with anxiety and depressive symptoms are 23.59 (p=.010) and 18.97 (p=.048) times more likely to complain of cognitive impairment, respectively (Table 2).

Figure 2. *Post head injury symptoms profile of patients with Complicated Mild and Moderate Traumatic Brain Injury*



In regard to somatic symptoms, only injury severity was found to be a significant predictor in the presence of somatic post-head injury symptoms. This indicates that patients with complicated mild TBI are 10.43 (p=.042) times likely to report the presence of somatic symptoms with reference to moderate TBI patients (Table 2).

The logistic regression analyses indicated that HADS-A, HADS-D, and AIIMS memory scales may significantly predict post-head injury symptoms on the affective scale in participants with complicated mild-moderate TBI (Table 2). The patients with anxiety symptoms are 11.49 (P = 0.024) times, and patients with depressive symptoms are 9.44 (P = 0.022) times more likely to complain about the presence of post-head injury affective symptoms. Patients with memory impairment on the AIIMS memory scale are 7.56 (P = 0.030) times more likely to report post-head injury problems in the affective domain with reference to patients who scored typically on the AIIMS memory scale.

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Table 2 *Logistic Regression Model for RPCSQ Various Subscales, with neurocognitive, affective measures and injury severity*

	RPCSQ Subscales								
	Affective symptoms			**Somatic symptoms**			**Cognitive symptoms**		
Variables	**95 % CI**	**Odds ratio**	***p***	**95 % CI**	**Odds ratio**	***p***	**95 % CI**	**Odds ratio**	***p***
Severity of Injury	.06-156.62	3.13	0.568	**1.09-99.84**	**10.4**	**0.04**	.41-106.27	6.57	0.185
TMT-A[1]	.98-1.03	1.01	0.546	.16-14.45	1.53	0.711	**2.45-107.36**	**16.2**	**0.05**
Stroop	.54-15.81	2.93	0.212	.82-47.10	6.28	0.077	.99-1.046	1.02	0.067
AIIMS-M[2]	**1.22-46.23**	**7.5**	**0.03**	.32-13.48	2.08	0.444	.95-1.127	1.03	0.475
HADS-A[3]	**1.38-95.22**	**11.5**	**0.02**	.10-1.05	1.02	0.092	**2.13-261.33**	**23.6**	**0.01**
HADS-D[4]	**1.34-64.75**	**9.44**	**0.02**	.43-26.28	3.38	0.245	**1.03-349.51**	**19**	**0.05**

Discussion

Literature pertains that post-head injury symptoms are the primary cause of long-term functional impairment after TBI. In the present study, a considerable number of patients had neurocognitive functional impairments, as a significant proportion of patients have problems performing standardized neurocognitive tasks. Head injury exerts reparation, which changes the brain's neural network, resulting in the impairment of neurocognitive function. Epidemiological studies suggest that due to the mechanical forces and anatomical morphology of the skull in head injury primarily impacts the frontal and temporal lobes (Mahaptara & Kamal, 2014). These frontal-temporal lobes are the important regions for normal cognitive functions of the brain. This supports the present study's findings, indicating impairment in those cognitive tasks that require higher-order frontal and temporal lobe functions.

The present study reveals that a considerable number of participants with complicated mild to moderate TBI had psychological distress and post-head injury symptoms in the form of headache, forgetfulness, and irritability. These findings are corroborated by earlier studies conducted on TBI patients (Chaurasiya et al., 2021a). Several researchers have reported that headache is the most common symptom after TBI because of changes in the brain caused by the injury (Chaurasiya et al., 2021b). Further, impulse control difficulty and trying to do multiple things at a time were common triggering factors for irritability in TBI patients (Hammond et al., 2016). Literature specifies that patients with TBI interpret their cognitive functioning impairment as impaired memory functioning (Polinder et al., 2018), which might be why patients reported forgetfulness as the most frequent problem after TBI.

The present study pertains to the fact that impairment in attention leads to cognitive symptoms in participants with complicated mild to moderate TBI. Researches indicate that attention is a basic function of the cognitive process, and impairment in this function may lead to problems in day-to-day overall cognitive functions. Further, attentional issues serve as a functional precondition for the expression of higher cortical functions, as attention is a basic cognitive process required for organizing and directing cognitive activities, integrating sensory input, and regulating emotional responses. Thus, disruptions in attentional processes can lead to cognitive overload and reduced cognitive efficiency (Luria, 1976). Therefore, problems in attentional function may lead to overwhelming complaints of cognitive symptoms in participants with complicated mild to moderate TBI.

The findings of the present study indicate that neurocognitive performance contributes to the cognitive aspect of post-head injury symptoms. These findings can be interpreted in the light of the coping hypothesis, which suggests that after injury, patients try to perform the task at their premorbid level of functioning. This requires vast mental effort to perform tasks as of premorbid level, and lesser performance results in underrating the cognitive functioning in TBI patients, leading to psychological distress and further exaggerated symptoms (Gould et al., 2014).

Furthermore, studies have suggested that preoccupied TBI-related distressing thoughts interfere with the cognitive functioning of patients (Boals & Banks, 2012; Eysenck et al., 2007). Coping with these unwanted worrisome thoughts reduces the available mental attentional resources because individuals have to shift and divide their attention between this ruminative thought and neurocognitive functional tasks. This leads to impaired cognitive performance in daily life. Hence, TBI patients report persistent cognitive symptoms post-injury.

Furthermore, the current study indicates that post-head injury physical symptoms are predicted by injury severity in participants with complicated mild to moderate TBI. In this regard, a relatively new finding in the study notices that patients with moderate head injury are less likely to suffer physical symptoms as compared to patients with complicated mild TBI. Studies have suggested that patients with severe injury have less awareness related to injury than patients with mild injury (Hart et al., 2005). Mild brain injury (MBI) patients often have better self-perception about their impairment compared to those with more severe injuries, which leads to an exaggerated perception and experience of physical symptoms due to heightened self-awareness and psychological factors, where increased focus on symptoms results in amplified symptom perception. Further, underlying neurophysiological mechanisms such as neuroplastic changes and increased cognitive load, HPA axis dysregulation and elevated stress hormone levels, chronic stress, and neuroinflammation with the release of pro-inflammatory cytokines contribute to this phenomenon by creating a feedback loop where heightened sensitivity and awareness in milder brain injury patients perpetuate and amplify the experience of impairments. Mild injury patients have self-perception about impairment and may have the capacity to discuss deficits; thus, this capacity leads to exaggerated perception and experience of physical symptoms in less severely injured patients (Hart et al., 2005). Another possibility includes that patient with a higher severity of injury receive a greater degree of reassurance from medical staff than comparatively less severely injured patients (Panenka et al., 2015). This might be the parsimonious reason that moderate brain injury patients have reported fewer physical symptoms than complicated mild brain injury patients.

In the present study, psychological distress emerges as a major determinant in emotional symptoms of post-head injury symptoms. The parsimonious reason could be that the subdomains of emotional post-head injury symptoms are pretty similar constructs of psychological distress, as these emotional post-head injury symptoms are related to complaining about feeling depressed, anxious and hopelessness. Furthermore, impairment in memory also predicts emotional symptoms after injury in participants with complicated mild-moderate TBI. Memory function problems could interfere with individuals' ability to perform day-to-day activities. This results in difficulties in managing emotional experiences as well, thereby increasing vulnerability to developing emotional symptoms in participants with complicated mild-moderate TBI. In patients with TBI, impairments in memory are closely linked to the development of emotional symptoms following the injury. Problems in TBI patients, such as difficulty in recalling past events, especially emotional events, may cause confusion and anxiety, while the inability to remember positive experiences contributes to feelings of depression. Memory impairments disrupt the normal emotion regulation process, leading to inappropriate or exaggerated emotional responses. Chronic stress, stemming from memory struggles, further impairs the functioning of the hippocampus, creating a vicious cycle of stress and memory difficulties. These issues are exacerbated by injury in the cortex, which is crucial for processing and regulating emotions. Further, several disruptions in neurotransmitter systems like dopamine and serotonin in TBI patients may further complicate the interplay between memory and emotional regulation (McAllister, 2011; Smith et al., 2013; Levin & Diaz-Arrastia, 2015). This highlights the need for planning rehabilitation strategies that address both cognitive and emotional aspects to improve recovery for TBI patients.

The findings of present study indicate that psychological distress contribute more to head injury symptoms than neurocognitive impairment. Literature pertains that anxiety and depression can significantly exacerbate post-TBI neurocognitive symptoms by influencing cognitive processes and pathophysiological mechanisms, such as increasing cognitive load through impaired attention and executive functions, slowing cognitive processing speeds, and reducing cognitive flexibility. Further, in terms of pathophysiology, psychological distress may worsen neuroinflammation and create Hypothalamic-Pituitary-Adrenal axis dysregulation, which exacerbates neurotransmitter imbalances and increases glutamate excitotoxicity. These conditions heighten sensitivity to negative events or feelings, increase emotional reactivity, and cause negative cognitive biases, all of which severely complicate emotional regulation (Silverberg & Iverson, 2011; Bombardier et al., 2010; Gould et al., 2011) that may increase psychological distress in TBI patients. Some researchers have indicated that cognitive impairments are more prominent in the early phase of injury, whereas psychological distress tends to develop in the later stage of an injury (Cole & Bailie, 2016; Whiting et al., 2006), and therefore, this is related to emerging awareness about cognitive impairment. This is supported by findings that people with distress symptoms underestimate their personal coping resources, and this insight elevates more symptoms. The coping hypothesis, as discussed by Gould (2014), indicates that dysfunctional cognitions—such as negative self-talk, catastrophic thinking, and rigid thought patterns—interfere with effective coping mechanisms by consuming cognitive resources, leading to cognitive overload, emotional dysregulation, and avoidance behaviours, which impair higher cognitive functions, thereby exacerbating symptoms and reducing the ability to manage distress effectively. This supports the findings that only the information about the neuropsychological functioning of patients is not enough to address cognitive rehabilitation strategies (Cicerone, 2012; Rath et al., 2004). Patients' self-appraisal, perception regarding performance, and confidence in their cognitive functioning are also important to address (Schutz & Trainor, 2007). Thus, a holistic approach that combines cognitive rehabilitation and psychotherapy is a gold-standard treatment to improve TBI patients functioning (Silver et al., 2009).

However, this is the preliminary study to find out the predictor of post-head injury symptoms in participants with complicated mild-moderate TBI. The study's findings must be interpreted with the caveat of the small sample size of this subgroup. This hypothesis-driven study on a small sample is limited in generalizability due to low significance and power efficacy. However, these findings shed light on the role of neuropsychological factors in post-head injury symptoms of complicated mild-moderate TBI patients, which has been a less studied phenomenon in these patients' groups. Further, expectancy biases might constrain the generalizability of the present findings. There is clearly a need for a prospective longitudinal study to investigate the predictors of persistent head injury symptoms and factors that may hinder or facilitate recovery. Furthermore, the effects of preinjury functioning (Chaurasiya et al., 2022) on recovery of head injury symptoms and neurocognitive functioning should be the aim of future research endeavours.

Conclusion

In the present study, our research hypothesis has been partially accepted as psychological distress was found to predict cognitive and affective symptoms but not somatic symptoms. Furthermore, injury severity predicted only somatic symptoms in complicated mild-moderate TBI patients. In the context of the role of neurocognitive functions in post-head injury symptoms, this was found that attentional functions play a major role in cognitive symptomatic complaints and memory in affective symptomatic complaints. The present study signifies the need to address psychological distress and symptomatic sequelae for these patients. Most studies on brain injury patients in Indian settings have investigated injury-related acute-stage symptoms (Agrawal et al., 2016; Chaurasiya et al., 2021a). Therefore, the findings of the present study are particularly important in neuro-rehabilitative settings that assess long-term symptoms and suggest that affective sequelae along with neurocognitive function must be addressed during the planning and execution of the rehabilitative efforts aimed at resolving post-head injury symptoms in participants with complicated mild-moderate TBI.

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