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Traumatic Brain Injury Screening: Preliminary Findings in a US Army Brigade Combat Team

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Objectives: The objective of this article is to report the proportion of soldiers in a Brigade Combat Team (BCT) with at least 1 clinician-confirmed deployment-acquired traumatic brain injury (TBI) and to describe the nature of sequelae associated with such injuries. **Participants:** Members of an Army unit ($n = 3973$) that served in Iraq were screened for history of TBI. Those reporting an injury ($n = 1292$) were further evaluated regarding sequelae. Of the injuries suffered, 907 were TBIs and 385 were other types of injury. The majority of TBIs sustained were mild. **Methods:** Postdeployment, responses to the Warrior Administered Retrospective Casualty Assessment Tool (WARCAT) facilitated clinical interviews regarding injury history and associated somatic (ie, headache, dizziness, balance) and neuropsychiatric symptoms (ie, irritability, memory). Traumatic brain injury diagnosis was based on the American Congress of Rehabilitation Medicine mild TBI criteria, which requires an injury event followed by an alteration in consciousness. **Results:** A total of 22.8% of soldiers in a BCT returning from Iraq had clinician-confirmed TBI. Those with TBI were significantly more likely to recall somatic and/or neuropsychiatric symptoms immediately postinjury and endorse symptoms at follow-up than were soldiers without a history of deployment-related TBI. A total of 33.4% of soldiers with TBI reported 3 or more symptoms immediately postinjury compared with 7.5% at postdeployment. For soldiers injured without TBI, rates of 3 or more symptoms postinjury and postdeployment were 2.9% and 2.3%, respectively. In those with TBI, headache and dizziness were most frequently reported postinjury, with irritability and memory problems persisting and presenting over time. **Conclusion:** Following deployment to Iraq, a clinician-confirmed TBI history was identified in 22.8% of soldiers from a BCT. Those with TBI were significantly more likely to report postinjury and postdeployment somatic and/or neuropsychiatric symptoms than those without this injury history. Overall, symptom endorsement decreased over time. **Keywords:** *assessment*, *blast*, *combat*, *deployment*, *Iraq*, *sequelae*, *symptoms*, *traumatic brain injury*

TRAUMATIC BRAIN INJURY (TBI) is often discussed as a common injury of the war in Iraq.[1] The reasons for this include the widespread use of explosive weapons in the war zone and the potential causal relationship between blasts from explosive munitions and TBI,[2–4] the increased survival rate due in large part to advances in body armor and helmets,[1] and the greater likelihood that mild TBI among military personnel wounded in this conflict will be diagnosed.[5] Previous research suggests that 65% of Operation Iraqi Freedom (OIF)-deployed soldiers have combat experience.[6] Such individuals are at risk for blast exposure and subsequent injury.[2] Gondusky and Reiter[2] evaluated battle injuries sustained by a battalion during OIF. Between March and August 2004, 32 attacks wounded 120 Marines who sustained 188 discrete injuries.[2] Ninety-seven percent of the injuries were the result of improvised explosive devices (65%) or mines (32%).[2] Explosive munitions generate an instantaneous rise in pressure over atmospheric pressure which creates a blast overpressurization wave.[1,7–10] Primary blast injury occurs secondary to an interaction between the overpressurization wave and the body, with differences occurring from

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one organ system to another.[8,9] In addition to injuries related to the barotrauma (primary blast injury), casualties may be sustained from projectiles and related structural collapse (secondary blast injury) and from soldier bodily displacement (tertiary blast injury).[1,2,4,9,11] Although research suggests that mechanical and blast-related injuries can occur in conjunction,[11] less is known regarding the relative contribution of each mechanism. Nevertheless, previous human and animal research suggests that barotrauma alone can be deleterious to the brain.[2–4,11] In studying survivors of the Balkan wars, Cernak et al[3] identified patients with blast-related neurological injuries characterized by abnormal neurological examination and electroencephalographic and neuroendocrine profiles. This finding was supported by a 2001 animal study, which confirmed blast-induced neurotrauma with associated performance deficits.[4]

Most civilian and military TBIs that occur are mild.[12,13] The majority of individuals are not hospitalized for such injuries.[13,14] One study analyzing survey data from a representative sample of US civilian households found that 25% of those who reported sustaining head injury that resulted in unconsciousness did not receive any medical assessment or treatment for their injury.[14] Nevertheless, such injuries are not inconsequential. Although for most individuals recovery can take up to 3 months,[15] studies have estimated that between 7% and 33% of those who sustain a mild TBI have symptoms that persist beyond this period of time.[16]

A limited amount of epidemiologic data about Operation Enduring Freedom/Operation Iraqi Freedom TBI have been published. One brief report focused on a hospitalized sample of more seriously injured patients treated at the major Army referral hospital in the United States and, therefore, is not representative of those who sustained injuries and remained in theater.[5] Another study used a cross-sectional anonymous questionnaire methodology to report on a sample of Army personnel who had completed an assignment in Iraq approximately 3 months previously.[17] To date, little is known about the incidence of clinician-confirmed TBI among military personnel serving in Iraq and the associated symptoms which may continue after soldiers' return to their home bases. This is in part related to the fact that TBI assessment can be difficult in a combat setting, particularly if medical systems are strained and/or the evaluation of non–life-threatening injuries is delayed.[18] Data about the incidence and outcomes of war-related TBI are necessary for determining the amount of burden TBI poses for individual service members and the military so that effective strategies for managing these TBI cases can be developed.

In both military and civilian populations, diagnostic challenges are potentially increased if medical records regarding TBI history are inaccessible or care for injuries was never sought.[19] As such, structured or in-depth interviews confirming an alteration in consciousness in the context of an injury is currently accepted as the "gold standard" for mild TBI diagnosis.[19,20] Ideally, such interviews would be conducted by individuals with training in TBI, thereby allowing for increased diagnostic accuracy.

However, when assessing a large number of people, a validated screening tool is desirable. Preliminary work in this area has been completed by Schwab and colleagues[18] using a 1-page questionnaire called the Brief Trauma Brain Injury Screen (BTBIS). For soldiers returning from Iraq and/or Afghanistan, the consistency of TBI reporting across instruments, including the BTBIS, was analyzed. Eighty-three percent of those who were located for follow-up interview and had self-reported altered mental status consistent with TBI on the BTBIS provided details of the injury to the clinical interviewer that confirmed the mild TBI criteria. Furthermore, soldiers who screened positive on the BTBIS alone were as likely during the interview to provide injury details that were consistent with standard mTBI criteria as soldiers who screened positive for TBI on the BTBIS on one or both of the longer questionnaires.

During the Post-Deployment Health Assessment (PDHA), returning military personnel complete a questionnaire designed to gather information about their present health status, as well as their exposure, while deployed, to numerous illness-producing risk factors such as combat stress and environmental hazards. Days after returning to their home bases from a deployment overseas, all military personnel are required to participate in this process. Since June of 2005, the PDHA evaluation process at Fort Carson has included screening for mild TBI. Toward this end, soldiers complete a brief questionnaire, which is used to facilitate an interview by a multidisciplinary team of clinicians.

This article presents findings from a retrospective analysis of TBI-specific data gathered with a questionnaire,[21] the Warrior Administered Retrospective Casualty Assessment Tool (WARCAT), and confirmed by clinical interview. At Fort Carson, the combination of the WARCAT and clinical interview are referred to as the WARCAT Plus. The PDHA was performed at Fort Carson, Colorado, with a US Army brigade combat team (BCT) that served 1 year (2004–2005) in Iraq. This article presents the proportion of soldiers in this BCT returning from deployment who sustained at least 1 clinician-confirmed TBI, with those reporting an injury (non-TBI) as the comparison group. Some soldiers (eg, those who were medically evacuated or had left the army) were not included in the presented sample. Related somatic (ie, headache, dizziness, balance problems) and neuropsychiatric (ie, irritability, memory problems) symptoms at the time of injury and at PDHA are reported.

METHODS

Participants

All members of 1 US Army BCT ($n = 3973$) who returned to Fort Carson, Colorado, from a 1-year deployment in Iraq were administered the WARCAT during their PDHA. It was the unit's first deployment to a combat zone during the present conflict. Soldiers with a clinician-confirmed injury event ($n = 1292$) received further screening regarding sequelae. Members of this group included those with at least 1 combat-acquired TBI ($n = 907$) and those with an injury event but no TBI ($n = 385$).

Instrument

The WARCAT,[21] based on the BTBIS,[18] was developed at Fort Carson. Soldiers completed the questionnaire indicating whether they were injured from mechanisms commonly associated with TBI while deployed, whether any injuries resulted in an altered mental status indicative of TBI, and/or whether specific somatic and neuropsychiatric symptoms commonly associated with mild TBI occurred after the injury (immediately postinjury and/or postdeployment). The somatic and neuropsychiatric symptoms were not used to make the diagnosis of TBI but rather to determine the frequency of sequelae between groups of injured soldiers with and without TBI. Specific symptoms queried included headaches, dizziness, memory problems, balance problems, and irritability. Items regarding 2 other symptoms, ringing in the ears and sleep problems, were also on the questionnaire but were not included in the presented analysis secondary to their expected frequency among returning combat Soldiers.

Procedures

After completing the WARCAT, all soldiers had at least one interview with a clinician. Master's- and doctoral-level providers who had received training in TBI queried soldiers to clarify whether they had sustained an alteration in consciousness in the context of an injury. This definition of mild TBI is consistent with that articulated by the American Congress of Rehabilitation Medicine.[22] During the interview, the WARCAT and all available medical records (eg, from deployment) were reviewed. The clinicians also confirmed the details of the injury event (eg, distance from explosives, whether the helmet stayed on, whether others were injured in the incident). Collateral information from battle buddies obtained by clinicians confirming the recalled history of the injury event and the possible alteration in consciousness was also used. Moreover, if during the course of the PDHA other injuries were identified that were thought to increase the likelihood that the individual had also sustained a TBI (eg, ruptured eardrums), the Soldier Readiness Center (SRC) clinicians queried regarding a potential combat-related TBI history regardless of the Soldier's initially endorsed responses. If discrepancies existed between results of the WARCAT and the interview questionnaire responses were changed to be reflective of clinicians' findings. All soldiers had at least one SRC Clinical interview.

The design of the WARCAT did not allow for the injury mechanism to be directly associated with the history of TBI. Questions regarding injury events and alteration in consciousness were not linked. That is, although clinicians did confirm the history of TBI and made changes as indicated on the WARCAT, they were not instructed to note specific dates by injury event(s). As a result, if the soldier sustained multiple injuries it was not possible to clarify the particular mechanism of injury responsible for the TBI.

The above-described process combined the advantages of a self-report survey, clinical interview, and collateral information for identifying individuals with TBI, which may not have been previously recognized. In the end, WARCAT Plus injury and sequelae data were used in analyses. Demographic and military characteristics were obtained from a separate database, Army Medical Surveillance Activity.

All soldiers diagnosed with clinician-confirmed deployment-related TBI were provided with educational materials regarding mild TBI,[21] including the expectancy of recovery and strategies to decrease distress during the recovery period. Individuals who were experiencing any type of health problem, regardless of whether or not they had a TBI, were referred to the appropriate healthcare providers for further assessment and treatment.

ANALYSIS

This analysis was approved by the Brooke Army Medical Center Clinical Institutional Review Board. Chi-square tests were used to compare data for those with and without TBI. The analysis regarding time since injury was conducted using a student's t test. Data are reported as means, standard deviations, and percentages, as appropriate. The analyses of somatic and neuropsychiatric symptoms included 5 TBI-related symptoms: headache, dizziness, balance problems, irritability, and memory problems. Multiple logistic regression was used to examine the effect of TBI status on having 1 or more mild TBI symptom immediately after injury and after returning from deployment while controlling for demographic and military characteristics (ie, gender, age, education, rank, and military occupational specialty). Injured soldiers for whom any demographic or military characteristics were unknown were excluded from the

TABLE 1 *Screening results**

Injury status	
Injured with TBI	907 (22.8)
Injured without TBI	385 (9.7)
Not injured	2681 (67.5)
Total Screened	**3973 (100)**
Injury characteristics for those with TBI†	
Dazed or confused only	572 (63.1)
Had loss of consciousness or could not remember the injury	335 (36.9)
Total with TBI	**907 (100)**

*Values represent *n* (%). TBI indicates traumatic brain injury.
†TBI is defined as an injury event followed by an alteration in consciousness such as being dazed or confused, not remembering the injury event, and/or losing consciousness.

logistic regression analyses. All independent variables were entered together. Categorical independent variables with more than 2 categories, such as education, age, and rank, were initially entered into the regression models as covariates to measure their overall effect on symptom risk. If a categorical variable with more than 2 categories was associated with symptom status in the initial analysis, the analysis was repeated with that variable entered as a categorical variable to identify the specific categories that were associated with symptoms.

RESULTS

Using the WARCAT Plus, the combination of the self-report and clinical assessment, 907 soldiers (22.8%) were diagnosed with a deployment TBI (Table 1). An additional 385 soldiers (9.7%) reported an injury but did not report a history consistent with TBI (ie, no alteration in consciousness). Injury characteristics of those with TBI are presented in Table 1. Blast was the most frequently reported injury mechanism (88.0%) by soldiers screening positive for TBI, followed by vehicular (39.0%), fall (20.0%), fragment (15.8%), and bullet (3.1%). Because some soldiers reported sustaining their injuries via multiple mechanisms, the percentages total more than 100. A limited number of soldiers provided a date of most serious injury. In the TBI group ($n = 338$ of 907), there was no significant difference in months since injury for those denying (mean = 5.6, SD = 3.4; $n = 131$) versus endorsing (mean = 5.9, SD = 3.2; $n = 207$) ($P = .965$) at least 1 symptom at the PDHA. The time since injury would not be greater than 12 months, since this was the length of the deployment and the screening occurred days after returning home.

Demographic and military characteristics of BCT soldiers by injury status are presented in Table 2. Data in Table 3 indicate that soldiers sustaining an alteration in consciousness during at least 1 injury event (deployment TBI) were significantly more likely to recall somatic and/or neuropsychiatric symptoms immediately postinjury and at follow-up than soldiers who had no alteration in consciousness during any of their injury events (no deployment TBI).

Multiple logistic regression analyses showed that clinician-confirmed TBI history was a significant predictor of mild TBI symptom status immediately after injury (adjusted OR = 35.2, $P < .001$) and after returning from deployment (adjusted OR = 5.1, $P < .001$) when controlling for demographic and military characteristics (Table 4). The omnibus χ^2 tests for both models were statistically significant ($P < .001$). Rank was the only other predictor of symptom status immediately after injury (adjusted OR = 1.4, $P = .048$), whereas age was the only other predictor of symptom status after returning from deployment (adjusted OR = 1.2, $P = .018$) (Table 4). Subsequent regression analysis of the effect of rank on symptom risk immediately after injury showed that only 1 category, senior noncommissioned officer (NCO), was associated with increased symptoms (adjusted OR = 3.4, $P = .021$). No other rank category was associated with symptom risk. A subsequent regression analysis of the effect of age on symptom risk after returning from deployment showed that the 25 to 29 age category was associated with increased symptom risk after returning from deployment (adjusted OR = 1.6, $P = .011$). The association between the 30 to 39 age category and symptom risk trended toward significance (adjusted OR = 1.5, $P = .056$). No other age category was associated with symptom risk. Military occupational specialty, gender, and education did not emerge as significant predictors of symptom status at either time period.

Change in the number of symptoms reported at injury and PDHA by soldiers with TBI is presented in Table 5. Table 6 shows the occurrence of specific mild TBI–related symptoms among soldiers determined to have a TBI, at 2 timeframes, right after the injury and after returning from deployment. The course of specific symptoms among soldiers with TBI is provided in Table 7.

DISCUSSION

Results from the current study indicate that 907 (22.8%) individuals from an Army unit had at least 1 clinician-confirmed TBI, most of which were mild in nature (Table 1). The most common mechanism of injury was blast, at 88%. Data in Table 3 show that those soldiers sustaining an injury event causing an alteration in consciousness (deployment TBI) were significantly more likely to recall targeted somatic and/or neuropsychiatric mTBI symptoms immediately postinjury and at

TABLE 2 *Demographic and military characteristics by injury status**

	Not injured (%) ($n = 2681$)	Injured without TBI (%) ($n = 385$)	Injured with TBI (%) ($n = 907$)
Age, y			
18–24	49.2	51.7	49.5
25–29	24.4	20.8	24.7
30–39	19.6	20.5	20.0
≥40	3.8	4.4	4.2
Unknown	2.9	2.6	1.7
Gender†,‡			
Male	91.3	93.8	98.0
Female	5.8	3.6	0.3
Unknown	2.9	2.6	1.7
Education‡			
No high school diploma	1.4	1.0	1.5
High school graduate	76.8	79.5	81.6
Some college	4.6	3.6	3.0
College graduate	10.3	9.1	7.5
Unknown	6.9	6.8	6.4
Military rank‡			
Junior enlisted	53.7	50.6	51.8
Mid-level noncommissioned officers	29.0	33.5	34.8
Senior noncommissioned officers	5.7	6.0	5.5
Warrant and commissioned officers	8.5	7.0	6.1
Unknown	3.0	2.9	1.8
Military occupational specialty†,‡			
Combat	31.9	41.3	54.5
Combat support (eg, engineer)	19.6	27.8	25.8
Support (eg, cook)	45.4	28.1	18.0
Unknown	3.0	2.9	1.8

*TBI indicates traumatic brain injury.
†Difference between TBI group and injured without TBI group is statistically significant, $P \leq .05$.
‡Difference between TBI group and not injured group is statistically significant, $P \leq .05$.

follow-up than Soldiers who had no alteration in consciousness during any of their injury events (no deployment TBI). The percentage of soldiers with TBI who reported 1 or more symptoms decreased dramatically (92.0% vs. 38.9%) from the time of injury to the time the BCT returned from Iraq (Table 3). Of note, 33.4% of soldiers with TBI reported 3 or more symptoms postinjury and 7.5% of soldiers with TBI reported 3 or more symptoms postdeployment. This is in comparison to those without TBI, of whom 2.9% reported 3 or more symptoms postinjury and 2.3% reported 3 or more symptoms postdeployment.

Multiple logistic regression analysis indicated that having a TBI was a risk factor for symptoms immediately after injury (adjusted OR = 35.2, $P < .001$) and after returning from deployment (adjusted OR = 5.1, $P < .001$) when controlling for demographic and military characteristics (Table 4). Only 1 rank category, senior NCOs, emerged as a risk factor for symptoms immediately after injury. This may be an anomaly because this category is small (about 6% of cases analyzed) and no other rank category was associated with increased symptom risk. The association between symptom risk and age appears to be stronger. One age category (25–29) emerged as an additional risk factor for symptoms after returning from deployment and this category comprised a larger proportion of the cases analyzed (about 25%) than the senior NCO category. The association between symptom risk after returning from deployment and another age category (30–39) trended toward significance and this was also a larger category than the senior NCO category. In this data set, military occupational specialty did not emerge as a predictor of mild TBI symptom status at either time period.

Because of the fact that the WARCAT focused on the presence or absence of common TBI sequelae, and not symptom severity or the relationship between symptoms reported and psychosocial functioning, the impact of either individual or clusters of symptoms is unknown. On the basis of existing definitions only soldiers endorsing 3 or more symptoms would meet criteria for post–acute syndromes or disorders related to a history

TABLE 3 *Number of injured soldiers with mild TBI symptoms* by injury status and time since injury†*

	n (%)	
	Injured with TBI (*n* = 907)	**Injured without TBI (*n* = 385)**
Number of mild TBI symptoms right after injury		
0	72 (7.9)	283 (73.5)
1	246 (27.1)	67 (17.4)
2	286 (31.5)	24 (6.2)
3 or more	303 (33.4)	11 (2.9)
Total With 1 or More Symptoms‡	**835 (92.0)**	**102 (26.5)**
Total With 2 or More Symptoms‡	**589 (64.9)**	**35 (9.1)**
Number of mild TBI symptoms after returning to the United States from deployment		
0	554 (61.1)	341 (88.6)
1	193 (20.2)	26 (6.8)
2	102 (11.2)	9 (2.3)
3 or more	68 (7.5)	9 (2.3)
Total With 1 or More Symptoms‡	**353 (38.9)**	**44 (11.4)**
Total With 2 or More Symptoms‡	**170 (18.7)**	**18 (4.6)**

*Mild TBI symptoms: headache, dizziness, balance problems, memory problems, and irritability.
†TBI indicates traumatic brain injury.
‡Difference between soldiers with and without TBI is statistically significant, $P < .001$.

TABLE 4 *Logistic regression results showing combined effects of TBI status and demographic and military characteristics on having 1 or more mild TBI symptoms among injured soldiers with and without TBI (n = 1208)*,†*

Variable	**Parameter estimate (β)**	**SE β**	**Wald**	***P***	**Adjusted odds ratio**	**95% CI adjusted odds ratio**
Had 1 or more mild TBI symptoms after injury‡						
TBI status	**3.561**	**0.182**	**383.141**	**.000**	**35.215**	**24.652–50.304**
Gender	−0.456	0.587	0.604	.437	0.634	0.201–2.002
Age	−0.031	0.117	0.068	.794	0.970	0.771–1.220
Education	−0.149	0.192	0.606	.436	0.861	0.592–1.294
Rank	0.303	0.153	3.992	.048	1.354	1.003–1.827
Military occupational specialty	0.132	0.115	1.331	.249	1.141	0.912–1.429
Constant	−0.056					
Had 1 or more mild TBI symptoms after returning from deployment§						
TBI status	**1.625**	**0.185**	**76.993**	**.000**	**5.080**	**3.533–7.303**
Gender	−0.172	0.698	0.061	.806	0.842	0.214–3.310
Age	0.213	0.090	5.623	.018	1.237	1.038–1.475
Education	−0.209	0.149	1.979	.159	0.811	0.606–1.086
Rank	−0.136	0.119	1.319	.251	0.872	0.691–1.101
Military occupational specialty	0.039	0.085	0.204	.651	1.039	0.879–1.229
Constant	−1.338					

*TBI indicates traumatic brain injury.
†Eighty-four injured soldiers were excluded because of unknown demographic or military characteristics.
‡Omnibus $\chi^2 = 542.998$, $P = .000$.
§Omnibus $\chi^2 = 113.106$, $P = .000$.

TABLE 5 *Number of soldiers with TBI reporting mild TBI symptoms* by time since injury and number of symptoms (n = 907)†*

Number of mild TBI symptoms after returning from deployment	Number of mild TBI symptoms right after injury, n (column %)			
	0	1	2	3 or more
0	63 (87.5)	177 (72.0)	192 (67.1)	122 (40.3)
1	4 (6.0)	53 (21.6)	55 (19.2)	71 (23.4)
2	3 (4.2)	12 (4.9)	25 (8.7)	62 (20.5)
3 or more	2 (2.8)	4 (1.6)	14 (4.9)	48 (15.8)
Total	72 (100)	246 (100)	286 (100)	303 (100)

679 (75.0%) reported fewer symptoms at postdeployment than at the time of injury.
123 (13.6%) reported the same number of symptoms at the time of injury and postdeployment.
39 (4.3%) reported more symptoms at postdeployment than at the time of injury.
63 (7.0%) reported zero symptoms at the time of injury and postdeployment.

*Mild TBI symptoms: headache, dizziness, balance problems, memory problems, and irritability.

†TBI indicates traumatic brain injury.

of brain injury.[23,24] Further research aimed at clarifying the impact of specific symptoms based on severity (eg, debilitating headaches) is warranted.

Soldiers in the Combat Arms Branches were more likely to sustain a TBI (Table 2). We also note that 44% of TBIs occurred in soldiers participating in combat support or support occupational specialties. Thus, a fluid battlefield and lack of a defined front places all soldiers at risk.

Headache (81.3%) and dizziness (59.3%) were identified as being the predominant symptoms immediately after injury (Table 6). These findings are consistent with previous research.[25,26] According to the World Health Organization Collaborating Centre Task Force on mild TBI, there is consistent evidence that adults experience headaches in the acute stage and months following TBI.[25] In collegiate football players who sustained concussions, headache was the most commonly reported symptom at the time of injury (85.2%) followed by problems with balance/dizziness.[26] In returning soldiers, symptoms that most frequently resolved by time of postdeployment included dizziness (93.7%), balance problems (84.7%), and headaches (77.3%) (Table 7). Although a number of soldiers denied memory problems and irritability in the acute stage, 52.3% and 48.6%, respectively, endorsed such symptoms postdeployment (Table 7). The later onset of memory problems and irritability may be related to challenges that arise as individuals return home. In addition, increases in neuropsychiatric symptoms (eg, verbal aggression and depression) over time have been previously noted in a military population of more severely injured patients with TBI.[27]

TABLE 6 *Specific mild TBI symptoms reported by soldiers with TBI by time since injury (n = 907)**

Symptom	Time since injury: Right after injury, n with symptoms (%)†	Time since injury: After returning from deployment, n with symptoms (%)†
None	72 (7.9)	554 (61.1)
Headache	737 (81.3)	183 (20.2)
Dizziness	538 (59.3)	46 (5.1)
Balance problems	235 (25.9)	58 (6.4)
Irritability	231 (25.5)	193 (21.3)
Memory problems	165 (18.2)	148 (16.3)

*TBI indicates traumatic brain injury.

†Percentages total more than 100 because many soldiers had multiple symptoms.

TABLE 7 *Course of specific symptoms among soldiers with TBI after returning from deployment ($n = 844$)*,†*

Symptom characteristic	Symptom				
	Headache	**Dizziness**	**Balance problems**	**Irritability**	**Memory problems**
Had symptom right after injury					
Resolved by time of return from deployment	570 (77.3)	504 (93.7)	199 (84.7)	139 (60.2)	89 (53.9)
Persisted to time of return from deployment	167 (22.7)	34 (6.3)	36 (15.3)	92 (39.8)	76 (46.1)
Total	737 (100)	538 (100)	235 (100)	231 (100)	165 (100)
Had symptom after returning from deployment					
Persisted from time of injury	167 (91.3)	34 (73.9)	36 (62.1)	92 (47.4)	76 (51.4)
New symptom, not present at time of injury	16 (8.7)	12 (26.2)	22 (37.9)	101 (52.3)	72 (48.6)
Total	183 (100)	46 (100)	58 (100)	193 (100)	148 (100)

*Eight hundred forty-four soldiers reported at least 1 or more symptoms at one or both times. Sixty-three soldiers denied symptoms at both times. Because individuals may have endorsed more than 1 symptom, totals are greater than 844. TBI indicates traumatic brain injury.
†Values are *n* (%).

Nevertheless, the seemingly nonspecific nature of these symptoms creates challenges for professionals attempting to clarify etiology.[28] Overall, the findings highlight the evolving nature of symptoms postinjury and suggest that obtaining early and precise information regarding symptoms endorsed immediately after TBI may facilitate accurate diagnosis. That is, specific acute and residual symptom profiles may improve TBI identification.

In summary, this study revealed that TBI was relatively common in this BCT. Most soldiers with TBI reported that symptoms remitted; however, 38.9% endorsed at least 1 mild TBI-related symptom at the PDHA. While some symptoms tended to present more frequently, and resolve with time (headache, dizziness, and balance problems), other symptoms were more persistent (irritability and memory problems) and nearly half of the time developed or were noted after the acute phase. This may have been because some of the symptoms were not realized until novel tasks were required or feedback from individuals who knew the soldier prior to deployment was received.

At Fort Carson, identified symptoms were addressed in a stepwise approach in a primary care setting. Individuals who were determined to have TBI were provided with educational materials and symptom treatment plans based on existing Centers for Disease Control and Prevention recommendations.[12] Educational intervention included information regarding the expectation for recovery. In the studied BCT, 39% of total TBI group received follow-up medical attention. This model of care is supported by the work of Ponsford and colleagues who found that those who received early intervention after mild TBI, including increased monitoring and education, reported fewer symptoms than those who did not.[29] Treatment at Fort Carson paralleled the stepwise postdeployment screening process proposed by Engel and colleagues.[30] In the absence of significant behavioral health disorders, sleep disturbance and headaches were addressed first. Intervention for irritability followed, with soldiers being prescribed medications as needed. Generally, reported cognitive difficulty was not formally assessed and/or treated until issues related to sleep, pain, irritability, and behavioral health were sufficiently addressed. Soldiers identified with TBI were encouraged to return with support persons (eg, family members, friends) for further evaluation, education, and the opportunity for clinicians to obtain collateral information with regard to symptom reporting and current functional status.

Results from this study share some limitations with previously published projects in which retrospective self-report was utilized to study history of TBI.[31,32] Although self-report is a frequently used methodology in the identification and study of mild TBI,[14,20,31,32] the reported outcomes may have also been impacted by the fact that soldiers were asked to recall subjective information about events in which disrupted brain functioning is inherent. For career soldiers, military-related pressures (eg, wish to return to duty or desire to leave the Army) may have also impacted reporting. The reality that many of the TBIs were sustained during combat also begs the question of whether symptoms recalled were wholly or in part related to other deployment-related medical or psychiatric conditions including posttraumatic stress. Development of alternate diagnostic and perhaps more objective measurement (eg, biomarkers, newer imaging techniques) may eventually provide a less subjective "gold standard" for mild TBI diagnosis. The fact that data were collected as part of routine clinical care for postdeployment soldiers may have also impacted findings. Not all service members with more severe TBI who returned prior to the end of the deployment participated in the PDHA process at Fort Carson and as a result were not included in the presented sample. Findings may have also been limited by the fact that participants were asked about 7 potential sequelae of which 5 were used in the analysis. As indicated above, responses regarding ringing in the ears and sleep problems were not included secondary to the nonspecific nature of these symptoms among returning combat soldiers. Therefore, the findings likely underestimate the percentage of these soldiers with multiple symptoms or post–acute disorders. As a result, further research to both determine the validation of this and other screening programs and address the impact of substance abuse, psychiatric history, and predeployment history of TBI, including the number, severity, and consequence, is indicated.

CONCLUSIONS

The goal of our study was to evaluate the proportion of soldiers in a BCT who sustained at least 1 mTBI and to compare that against soldiers sustaining an injury without having a TBI. Our preliminary results show that approximately 1 in 5 returning soldiers serving in Iraq for 1 year had a history of deployment-related TBI. For the majority of soldiers, mild TBI symptoms resolved over time; however, nontrivial levels of sequelae persisted or were identified postinjury. Such symptoms may in part be related to the development of comorbid behavioral health issues. Future TBI research must focus on the relationship between potential objective markers of combat-related TBI (eg, neuropsychological testing and neuroimaging), subjective modalities (eg, self-report measures), and long-term functioning postinjury. The relationships between the intensity and frequency of exposure to blast, number of TBI events, and injury severity and course are also indicated. At present, the prevalence natural history, relationship to mental health symptoms, and long-term prognosis of deployment-related TBI remain unknown. We do believe that early recognition and treatment is the key to both decreasing enduring TBI sequelae and improving outcomes (eg, increased work performance) in soldiers with positive TBI histories. Although it is not always possible in combat environments, soldiers may benefit most if the assessment and intervention occur as close as possible to the time of injury.

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