Blast-related Mild Traumatic Brain Injury is Associated with A Decline in Self-rated Health amongst US Military Personnel

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Blast-related mild traumatic brain injury is associated with a decline in self-rated health amongst US military personnel

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ABSTRACT

Introduction: Mild traumatic brain injury (MTBI) has emerged as the preeminent injury of combat from the recent conflicts in Iraq and Afghanistan. Very little is known about short- and long-term outcomes after combat-related MTBI. As a measure of outcome after injury, self-rated health is a reliable, widely used measure that assesses perceived health. The primary aim of this study was to determine the effect of combat-related MTBI on self-reported health status after return from deployment. The secondary objective was to examine predictors of a decline in self-reported health status amongst US service members with MTBI, as compared to those service members with other minor non-TBI injuries.

Patients and methods: MTBI cases and an injured comparison group were identified from the Expeditionary Medical Encounter Database records of 1129 male, US service members who experienced blast-related injuries in Iraq from March 2004 to March 2008. Self-rated health was assessed from the routinely administered pre- and post-deployment health assessment questionnaires by the following question, "Overall, how would you rate your health during the past month?" Possible responses were "poor", "fair", "good", "very good", or "excellent." A distinction was made between minor and major negative changes in health (i.e., very good to fair) based on these self-rated health outcomes captured post-injury.

Results: For all personnel, post-injury levels of self-rated health were statistically significantly worse than pre-injury health rating. At 6 months post-injury, service members with MTBI were 5 times more likely to report a major negative change in health as compared to members with other mild injuries. This association was independent of age, rank, branch of service, Injury Severity Score, mental health diagnosis prior to injury, and having been referred to a health care professional.

Discussion: Blast-related injuries, specifically MTBI, during deployment have negative consequences on service members' perception of health. Future research is needed to improve our understanding of the overall effects of MTBI on health and quality of life.

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Introduction

Mild traumatic brain injury (MTBI) has emerged as the preeminent injury in the Iraq and Afghanistan conflicts, where a significantly higher percentage of head, neck, and facial wounds[1] have been observed as compared to previous wars.[2,3] Blast events account for nearly 70% of injuries in wounded service members in both Iraq and Afghanistan, and frequently result in MTBI.[4,5] This increase in blast events and subsequent battlefield-related MTBI has led to a heightened focus on the physical, psychological, and behavioural consequences. However, little is known about the short- and long-term outcomes of MTBI, specifically, self-rated health and quality of life.

Self-rated health is a valid, widely used, multi-dimensional measurement encompassing general well-being, physical, psychological, social, and cognitive functioning[6–10] and has been found to be a predictor of mortality amongst young, adult males.[11,12] Moreover, recent research has shown that there is a significant reduction in quality of life amongst TBI patients.[13] Patients with MTBI report significantly more post-concussive symptoms even when assessed months rather than weeks post-injury[14] and report a noticeable decline in self-rated health following injury.[15] Previous research on post-injury health-related quality of life is limited by inadequate assessment of pre-injury levels of self-rated health.[10,14,15] The US Military's implementation of standard health questionnaires prior to deployment allows for an estimate of pre-injury health.

The primary aim of this epidemiologic study was to examine the effect of combat-related blast injury on levels of self-rated health, and to assess the mediating effect of MTBI. The secondary objective was to investigate physical and mental health correlates

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for declines in self-rated health in US service members with MTBI compared to those with other minor non-TBI injuries.

Patients and methods

The study population included 1129 male US service members identified for the study who presented to forward-deployed medical treatment facilities (i.e., those in the combat zone and nearest to the point of injury) for blast-related combat injuries from March 2004 to March 2008. The study sample was identified from the US Expeditionary Medical Encounter Database (EMED), formerly the Navy-Marine Corps Combat Trauma Registry. The EMED is a deployment health database maintained by the Naval Health Research Center, in San Diego, CA. The database consists of documented clinical encounters of service members deployed in support of Operations Enduring and Iraqi Freedom.[1]

Injury-specific and demographic data

Injury severity was assessed using the Injury Severity Score (ISS) for each patient.[16] Only those with an ISS of one to eight were included in the present study. Patients with more than one injury event and those who died of wounds were excluded. Those in the MTBI group could have sustained other mild injuries in addition to the MTBI and the comparison group was comprised of those with mild non-TBI injuries. MTBI, the exposure of interest, was identified from the EMED records according to criteria established by the Centers for Disease Control and Prevention as indicated by any one of the following *International Classification of Diseases 9th Revision, Clinical Modification* (ICD-9-CM) codes: 800.0–801.9, 803.0–804.9, or 850.0–854.1.[17]

Inpatient and outpatient mental health diagnoses prior to injury (ICD-9-CM codes 290–316) were obtained from medical records managed by the Office of the Secretary of Defense, Health Affairs, TRICARE Management Activity (i.e., Standard Inpatient Data Record and Standard Ambulatory Data Record). Diagnoses were coded by credentialed providers at military treatment facilities and federally reimbursed private clinics using ICD-9-CM codes.[18] Marital status at the time of injury was obtained from the Defense Manpower Data Center. Age, military rank, and service at time of injury were extracted from the EMED clinical record. Rank was categorised as junior enlisted (E1–E4), enlisted (E5–E6), or senior enlisted/warrant officer/officer (E7–E9, W1–W4, or O1–O6).

Health assessment

Whilst preparing for deployment, all service members are administered a Pre-Deployment Health Assessment (PreDHA) to examine operational suitability. One of the questions assesses self-rated health status, by asking "Overall, how would you rate your health during the past month?" Possible responses were "poor", "fair", "good", "very good", or "excellent." After returning from deployment, a similar assessment, the Post-Deployment Health Assessment (PDHA), is completed.[19] The purpose of the PDHA is to evaluate service members' present health status, including mental health, and deployment-related and current health concerns. These concerns include post-traumatic stress disorder (PTSD) and health symptoms complaints. These symptoms include physical (i.e., weakness, back pain, feeling tired after sleeping, muscle aches, and painful joints), mental (i.e., PTSD or depression) and neurological (i.e., headache, dizziness, difficulty remembering, ringing in the ears, numbness in feet or hands and dimming of vision) complaints. The PDHA also allows a health care provider to refer personnel to a specialty health care service (i.e., neurology, mental health, etc.).

Health outcomes were categorised into three levels based on the negative change from pre- to post-injury level of self-rated health (i.e., very good to fair). A distinction was made between minor (one category reduction) and major (two category reduction) negative changes in health status, which provided a three-level outcome variable (major negative change in health, minor negative change in health, and no negative change). Referrals to health care professionals (yes or no and referral type) were analysed as a secondary outcome measure to assess health-related concerns.

Statistical analysis

The primary outcome variable was major or minor negative change versus no change in self-reported health status. Chi-square (χ^2) and Fisher's exact tests were used to assess the association of categorical variables with self-reported health status. Independent samples *t* tests were used to assess differences amongst continuous variables. The Wilcoxon matched pairs signed-ranks test was performed to determine statistical significance of change in levels of self-rated health from pre- and post-injury. The association of physical and mental health with time elapsed since injury ($<$6 months vs. $\geq$6 months) was assessed using χ^2 tests. Tests were two-tailed, and a P value of $<.05$ was used to determine statistical significance. The association of independent variables with a major or minor negative change in self-rated health were examined using multinomial logistic regression. Covariates ($P < .10$) and the independent variable of interest were entered into the final model to assess confounding. For selected analyses, an interaction term was included for time elapsed from injury to completing the PDHA. All statistical analyses were performed using SPSS software, version 17.0 (SPSS, Inc., Chicago, IL, USA).

Results

Demographic characteristics

Demographic characteristics of the 1129 male, US service members with blast-related mild injuries from March 2004 to March 2008 are shown in Table 1. Of these, 473 (41.9%) were MTBI and 656 (58.1%) had other minor non-TBI injuries. Mean age was 25.0 years and ranged from 18 to 56 years. Although patients with MTBI ($M = 24.4$, SD = 5.3) were statistically younger than those with other mild injuries ($M = 25.4$, SD = 6.0; $t = 2.97$, $P = .003$, $d = 1.0$), the age difference was small. Additionally, a significantly higher proportion of those with MTBI were Marines ($\chi^2 = 25.5$, $df = 2$, $P < .001$) and junior enlisted ($\chi^2 = 11.6$, $df = 3$, $P = .009$) compared to service members with other mild injuries. Conversely, patients without MTBI were affected by less severe injuries in comparison to those with MTBI ($t = 12.1$, $P < .001$, $d = 1.1$).

Referrals to health care professionals

In Table 2, referrals to health care professionals amongst service members reporting any decrease in self-rated health are shown. A lower proportion of referrals to health care professionals were made for service members with MTBI (51.1%) as compared to service members with other mild injuries (55.6%), but this difference did not reach significance. Service members with MTBI, not unexpectedly, did have a significantly higher proportion of neurological referrals compared to those with other mild injuries ($\chi^2 = 14.2$, $df = 1$, $P < .001$).

Self-rated health

Comparisons of pre- and post-injury levels of self-rated health are shown in Fig. 1. Post-injury levels of self-rated health were significantly worse than pre-injury status ($Z = 19.2$, $P < .001$).

Table 1
Descriptive characteristics of blast-related combat injuries amongst US service members ($N = 1129$).

Characteristics	Mild TBI ($n = 473$)		Other mild injuries ($n = 656$)		P
	N	(%)	N	(%)	
Mean age (SD), years	24.4	(5.3)	25.4	(6.0)	.003
Branch of service					<.001
Army	161	(34.0)	322	(49.1)	
Marine Corps	290	(61.3)	312	(47.6)	
Navy	22	(4.7)	22	(3.4)	
Rank					.009
E1–E4	326	(68.9)	430	(65.5)	
E5–E6	113	(23.9)	164	(25.0)	
E7–officers	20	(4.2)	54	(8.2)	
Unknown	14	(3.0)	8	(1.2)	
Marital status					.290
Single	285	(60.3)	398	(60.7)	
Married	178	(37.6)	234	(35.7)	
Other	10	(2.1)	24	(3.7)	
Mental health diagnosis prior to injury					.085
Yes	49	(10.4)	48	(7.3)	
No	424	(89.6)	608	(92.7)	
Mean injury severity score (SD)	2.9	(1.7)	1.8	(1.4)	<.001
Days from injury to health assessment					.077
0 days –3 months	187	(39.5)	268	(40.9)	
3–6 months	223	(47.1)	273	(41.6)	
≥6 months	63	(13.3)	115	(17.5)	

Table 2
Frequency distribution in referrals to health care professionals amongst US service members with any decline in self-rated health from pre-to post-deployment health assessment ($N = 638$).

Referrals	Mild TBI ($n = 278$)		Other mild injuries ($n = 360$)		P
	N	(%)	N	(%)	
Referral to health care professional					.261
Yes	142	(51.1)	200	(55.6)	
No	136	(48.9)	160	(44.4)	
Type of referral					
Cardiac	1	(0.4)	0	(0.0)	
Operational stress reaction	10	(3.6)	20	(5.6)	.247
Dental	15	(5.4)	28	(7.8)	.234
Dermatology	1	(0.4)	1	(0.3)	
Ear, nose, throat	9	(3.2)	14	(3.9)	.662
Eye	5	(1.8)	13	(3.6)	.170
Family problems	2	(0.7)	1	(0.3)	
Fatigue	13	(4.7)	24	(6.7)	.286
Audiology	40	(14.4)	41	(11.4)	.259
Gastrointestinal	0	(0.0)	2	(0.6)	
Genitourinary	0	(0.0)	1	(0.3)	
Mental health	28	(10.1)	40	(11.1)	.673
Neurologic	30	(10.8)	12	(3.3)	<.001
Orthopaedic	25	(9.0)	47	(13.1)	.108
Pulmonary	2	(0.7)	2	(0.6)	
Other	56	(20.1)	82	(22.8)	.423

Note. Blank P values reflect lack of sufficient sample size for chi-square statistic.

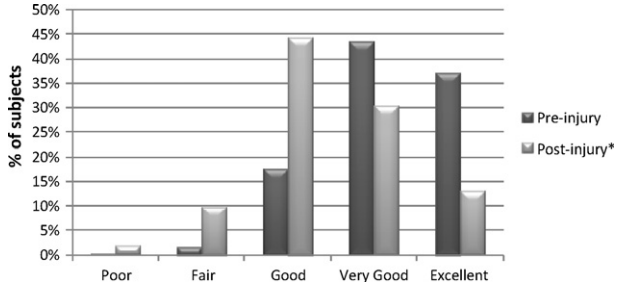

Fig. 1. Frequency distribution of pre- and post-injury levels of self-rated health ($N = 1129$). *Statistically significant difference Wilcoxon matched pairs signed-ranks test, $Z = 19.21$, $P < .001$.

There was a 38% difference in those who reported their health as excellent or very good at baseline (pre-injury) as compared to follow-up (post-injury). Health symptom complaints by changes in self-rated health are shown in Table 3. Service members reporting a major negative change in health had significantly more physical (55.0% vs. 42.7%, 27.7%; $\chi^2 = 54.6$, $df = 2$, $P < .001$), neurological (50.4% vs. 45.7%, 27.1%; $\chi^2 = 50.1$, $df = 2$, $P < .001$), and mental health (41.7% vs. 26.8%, 20.8%; $\chi^2 = 35.9$, $df = 2$, $P < .001$) symptom complaints compared with those reporting a minor negative change or no change in health, respectively.

Changes in self-rated health by time elapsed from injury are shown in Table 4. A significantly higher proportion of patients with MTBI reported a major negative change (41.3% vs. 16.5%) in health when completing a health assessment at least 6 months after injury as compared to those with other mild injuries ($\chi^2 = 13.7$,

Table 3
Frequency distribution of changes in self-rated health and symptom complaints amongst US service members ($N = 1129$).

Health complaints	Major negative change ($n = 242$)		Minor negative change ($n = 396$)		No negative change ($n = 491$)		P
	N	(%)	N	(%)	N	(%)	
Physical symptoms	133	(55.0)	169	(42.7)	136	(27.7)	<.001
Neurological symptoms	122	(50.4)	181	(45.7)	133	(27.1)	<.001
Mental symptoms	101	(41.7)	106	(26.8)	102	(20.8)	<.001

Note. Physical symptoms include endorsing at least one of the following: weakness, back pain, feeling tired after sleeping, muscle aches, and painful joints. Neurological symptoms include endorsing at least one of the following: headache, dizziness, difficulty remembering, ringing in the ears, numbness in feet or hands and dimming of vision. Mental health symptoms include endorsing posttraumatic stress disorder or depression.

Table 4
Changes in self-rated health by time elapsed from a deployment-related injury amongst US service members ($N = 1129$).

Self-rated health	Time elapsed from injury to health assessment							
	<6 months[a]				≥6 months[b]			
	Mild TBI ($n = 410$)		Other mild injuries ($n = 541$)		Mild TBI ($n = 63$)		Other mild injuries ($n = 115$)	
	N	(%)	N	(%)	N	(%)	N	(%)
Change in self-rated health								
Major negative change	86	(21.0)	111	(20.5)	26	(41.3)	19	(16.5)
Minor negative change	149	(36.3)	193	(35.7)	17	(27.0)	37	(32.2)
No negative change	175	(42.7)	237	(43.8)	20	(31.7)	59	(51.3)

[a] $P = .942$.
[b] $P = .001$.

$df = 2$, $P = .001$). Conversely, there was no difference in self-rated health amongst patients with MTBI and those with other mild injuries when completing a health assessment less than 6 months after injury ($\chi^2 = 0.12$, $df = 2$, $P = .942$).

Physical and mental health symptoms in those with MTBI versus the comparison group stratified by time elapsed from their injury (<6 vs. ≥6 months) were also assessed. Amongst patients with MTBI, a significantly higher proportion reported back pain than did those with other mild injuries (41.3% vs. 20.0%; $\chi^2 = 9.23$, $df = 1$, $P = .003$) after 6 months post-injury. Additionally, patients with MTBI also reported a significantly higher proportion of multiple PTSD symptoms as compared to those with other mild injuries (54.0% vs. 35.7%; $\chi^2 = 9.23$, $df = 1$, $P = .026$) (data not shown).

Association of selected risk factors with change in self-reported health

Table 5 shows a multinomial logistic regression analysis of selected risk factors for major and minor negative changes in self-reported health relative to those reporting no change. After adjusting for demographic, referral to a health care professional, and injury-specific variables, service members with MTBI, relative to those with other mild injuries, who completed the health assessment more than six months after injury were nearly five times as likely (odds ratio [OR] 4.87, 95% confidence interval [CI] 2.15–11.03) to indicate a major negative change in self-rated health. Further, after adjusting for all variables in the model, service members being referred to a health care professional in relation to those not being referred were significantly more likely

Table 5
Multivariable analyses of predictors in reduction of self-rated health amongst US service members sustaining a MTBI compared to other mild injuries ($N = 1129$).

Variables	Major negative change in health		Minor negative change in health		No negative change in health
	AOR	95% CI	AOR	95% CI	Reference
Age, years	0.98	0.94–1.01	0.99	0.96–1.02	Ref
Rank					
E1–E4	0.82	0.38–1.79	0.75	0.40–1.41	
E5–E6	0.92	0.44–1.93	0.71	0.39–1.29	
E7–officer					Ref
Branch of service					
Army	0.91	0.39–2.08	1.06	0.49–2.26	
Marines Corps	0.69	0.30–1.58	1.05	0.49–2.26	
Navy					Ref
Referral to health care professional					
Yes	1.74[a]	1.25–2.40	1.51[a]	1.15–2.00	
No					Ref
Mental health diagnosis prior to injury					
Yes	1.24	0.73–2.11	0.71	0.42–1.20	
No					Ref
Injury severity	0.97	0.87–1.08	0.99	0.90–1.08	Ref
Injury type × days from injury to health assessment					
MTBI vs. other mild injuries, ≥6 months	4.87[a]	2.15–11.03	1.48	0.67–3.31	Ref

Abbreviations. AOR, adjusted odds ratio; CI, confidence interval; MTBI, mild traumatic brain injury; ref, reference.
[a] $P < .05$.

to report a major or minor negative change in health (OR 1.74, 95% CI 1.25–2.40) (OR 1.51, 95% CI 1.15–2.00).

Discussion

Blast-related MTBI continues to be a predominant injury of modern warfare, although the effect of MTBI on subsequent health outcomes is unclear. Our findings provide evidence that MTBI is associated with significant declines in self-rated health at 6 months post-injury when compared to non-TBI injured personnel. The decline was independent of age, rank, branch of service, injury severity, mental health diagnosis prior to injury, and having been referred to a health care professional. Further, our findings suggest specific mental, neurological and physical symptoms such as weakness, back pain, headaches or PTSD may contribute to these declines. Knowledge of the specific symptom complaints may eventually lead to refinements in MTBI rehabilitative efforts.

Overall declines in self-rated health following MTBI are not altogether surprising, as previous studies in civilian populations have identified similar declines in quality of life following MTBI and other traumatic injuries.[15,20] The primary finding of our study was a time-dependent association between MTBI and declining self-rated health at six months post-injury. This finding contradicts civilian literature which points towards a gradual recovery for most people in the months following MTBI.[21,22] However, this civilian evidence is based primarily on blunt and sports-related head trauma and recovery from blast-related MTBI may vary as a result of the different mechanism of injury.

There are multiple theories explaining the time-dependent association between MTBI and declines in self-rated health. Larsson et al. suggested that significantly more post-concussive symptoms appear months, rather than weeks, after an injury.[11] This is supported in our analysis by the elevated back pain and PTSD symptoms amongst those with MTBI at 6 months post-injury, though we could not determine whether these were new onset symptoms or simply the persistence of previous symptoms. Symptoms of back pain and PTSD have both been reported previously in veterans with MTBI.[23] This may suggest a form of latent post-concussion syndrome that warrants further research. Alternatively, Lishman suggested that barriers to recovery may cause the symptoms of MTBI to persist.[24] Potential barriers may include concomitant PTSD symptoms,[25] as well as prolonged presence in a stressful and austere deployment environment. Moreover, this finding needs to be replicated in a larger study population to rule out the possibility that small sample size played a role in the results. There are secondary findings of interest. In the total sample, post-injury levels of self-rated health declined from pre-injury health rating. This is consistent with studies showing general declines in health related quality of life following an injury.[13,15] Additionally, those with MTBI had a significantly higher rate of referral for neurological services. This is not altogether surprising as post-concussive symptoms, particularly persistent complaints, would typically indicate a neurological assessment.

Our study has several strengths. To our knowledge this is the first study to elucidate changes in self-rated health before and after blast-related MTBI. It is often difficult to obtain an unbiased pre-injury measure of self-rated health, though we were able to accomplish this by using pre-deployment health assessment data ascertained prior to the date of injury and deployment. Further, the use of provider diagnosed MTBI eliminated the role of recall bias often inherent in other studies using self-reported injury information.

There were limitations that warrant mention. The data for this study population were collected from level I and II Navy-Marine Corps MTFs only (i.e., casualties treated at forward deployed Army facilities and those transported directly to Combat Support Hospitals from the point of injury were not included), which may not be representative of all injuries sustained during combat. An additional limitation is the categorisation of the self-rated health measure. The creation of categories for self-rated health reflecting minor and major changes was novel and not previously validated. However, we were able to show that changes in these categories were associated with a somewhat linear increase in self-reported physical, mental and neurological health complaints, suggesting that there may be utility in examining changes in self-rated health with this approach.

Conclusions

Blast-related combat injuries during deployment have negative consequences for service members' health. In addition to the existing knowledge that MTBI has physical, psychological, and behavioural consequences, our findings suggest that MTBI is associated with significant declines in self-rated health, though this effect is only evident at 6 months post-injury. Because self-rated health is a multi-dimensional measure,[6,7,9,12,26] interpreting the exact aetiology of declining self-rated health can be difficult. Thus future research should incorporate a prospective design with repeated measures to determine the independent influence of specific health domains, particularly physical, psychological, social, and cognitive functioning. As blast-related injuries persist in the current warfare environment, the short- and long-term outcomes of MTBI need to be further understood.

Conflict of interest statement

The authors report no conflicts of interest.

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14. ABSTRACT

Aims: The primary aim of this study was to determine the effect of combat-related mild traumatic brain injury (MTBI) on self-reported health status after return from deployment. Additionally, we examined predictors of a decline in self-reported health status among US service members with MTBI compared with other minor non-TBI controls injured in Iraq.
Design: Retrospective cohort study
Participants: Cases and controls were chosen from 1,129 male, US service members with blast-induced mild to moderate injuries from March 2004 to March 2008 and were identified from the US Expeditionary Medical Encounter Database.
Measures: Self-rated health was measured through the routine administration of pre- and post-deployment health assessment questionnaires and was assessed by, "Overall, how would you rate your health, during the past month?" Self-rated health outcomes were classified by subtracting the pre-injury from the post-injury level of health rating (ie, very good–fair).
Results: Overall, post-injury levels of self-rated health were significantly worse than pre-injury health rating. At 6 months' post-injury, service members with MTBI were four times more likely to report a two-level decrease in health compared to those with other mild injuries. The association was independent of covariates.
Conclusions: Blast-induced injuries, specifically MTBI, during deployment have negative consequences on service members' perception of health.

15. SUBJECT TERMS
mild traumatic brain injury, self-rated health, military, combat casualty

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