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Repeated concussion among U.S. military personnel during Operation Iraqi Freedom

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Abstract—Concussions are a predominant injury of the conflicts in Iraq and Afghanistan. The aims of this study were to describe repeated concussive events among U.S. military personnel injured in Operation Iraqi Freedom and examine subsequent healthcare utilization. We reviewed clinical records from the Expeditionary Medical Encounter Database to identify servicemembers with repeat concussions. We abstracted demographic and injury-specific variables, calculated time between events, and identified healthcare utilization from electronic medical databases. Overall, 113 personnel experienced more than one concussion between 2004 and 2008. A majority of these incidents were blast related. The median time between events was 40 days, with 20% experiencing a second event within 2 weeks of the first and 87% within 3 months. Time between events was not associated with severity of the second event. Greater severity of the second concussive event was associated with higher postinjury utilization of mental health and neurology services. This study is one of the first to describe repeated concussions in a combat setting. We found that repeated concussions occur within a short interval among deployed personnel, although the effects of the first event are unclear. Further research is needed to define the effect of repeated concussions on the health of combat veterans.

Key words: blast, combat, concussion, concussive injury, deployment, head injury, head trauma, military, multiple, severity, traumatic brain injury.

INTRODUCTION

Traumatic brain injury (TBI) is one of the predominant injuries of the current military conflicts in Iraq and Afghanistan, with prevalence ranging from 15 to 20 percent depending on the diagnostic criteria and patient population [1–7]. A majority of these injuries, 85 percent in one study, are mild concussions resulting from exposure to blasts [1–4,7]. Because military personnel with mild injuries are often returned to full duty status shortly after the injury-causing event, understanding the lasting effects on cognitive and physical functions, as well as the risks associated with repeat injury, is of significant importance [8].

Although research describing the effects of repeated concussions in military populations is limited, civilian literature points to several detrimental physical, cognitive, and emotional health effects of incurring multiple

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Abbreviations: AIS = Abbreviated Injury Scale; CI = confidence interval; EMED = Expeditionary Medical Encounter Database; ICD-9-CM = International Classification of Diseases, 9th Revision, Clinical Modification; ISS = Injury Severity Score; LOC = loss of consciousness; NHRC = Naval Health Research Center; OR = odds ratio; SADR = Standard Ambulatory Data Record; TBI = traumatic brain injury.

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concussions [9–13]. Evidence exists that some aspects of neurocognitive function do not recover as quickly in those who have experienced multiple concussions, and some studies suggest a permanent reduction in cognitive performance [14–15]. One recent study showed greater reduction in neurological activity among persons with two concussions, with reduced time between concussive events acting as an important mediator [16].

The aims of the present study were to (1) provide a descriptive analysis of repeated concussion in U.S. military personnel, (2) identify whether decreased time between events is associated with increased severity of the second event, and (3) identify predictors of postinjury utilization of mental health and neurology outpatient services following the second concussive event.

METHODS

Study Design

The present study was an analysis of servicemembers with repeated concussions that were reported in the Expeditionary Medical Encounter Database (EMED) (formerly the Navy-Marine Corps Combat Trauma Registry). The EMED is a deployment health database maintained by Naval Health Research Center (NHRC), San Diego, California, and consists of documented clinical encounters of deployed military personnel from all service branches (a more extensive description of the EMED can be found elsewhere [17]).

Data Sources

Clinical EMED records were completed by medical providers stationed at forward-deployed Navy-Marine Corps military treatment facilities that were located in Iraq to treat Operation Iraqi Freedom casualties. Unique aspects of the EMED include detailed information regarding the injury incident, which is collected at or near the point of occurrence, as well as the inclusion of persons with otherwise mild injuries who are subsequently returned to duty. Clinical records are provided to NHRC, and professional coders review the records and assign codes using the Abbreviated Injury Scale (AIS); Injury Severity Score (ISS); and International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) [18–20].

Study Sample

For the present study, eligible personnel were servicemembers who sustained two or more provider-diagnosed concussions during Operation Iraqi Freedom from March 2004 to April 2008. A concussion was defined by the presence of an ICD-9-CM code of 850.0 to 850.9. Severity of concussion was defined using the AIS, which is a scoring system that details the severity of each injury and is categorized into nine different body regions (i.e., head, neck, face, torso, abdomen, spine, upper limb, lower limb, and external) [18]. All personnel in the study sustained concussions corresponding to a maximum head AIS of 1 (minor injury) or 2 (moderate injury). At the time of the present study, 113 of 14,653 individuals in the EMED with combat or noncombat injury met the inclusion criteria and comprised the study sample. Overall injury severity for each servicemember was determined with the ISS, which is derived from the AIS and ranges from 0 to 75 [19]. Because of a small number of individuals with more than two concussive events ($n = 6$), analysis was restricted to the first two events.

Measures

Demographic Variables

Age, military rank, branch of service, and occupational specialty at the time of the initial concussive event were abstracted from the EMED clinical record and validated with information from the Defense Manpower Data Center, which maintains administrative records for all military personnel. Military rank was categorized as junior enlisted (E1–E3), midlevel enlisted (E4–E5), senior enlisted (E6–E9), and officer/warrant officer. Branch of service was categorized into Marine Corps, Army, and Navy. Occupation was defined as infantry or other/unknown based on indication of an infantry-related job specialty (general infantry, rifleman, mortarman, missileman, or machine gunner).

Injury-Specific Variables

Type of injury was categorized as combat, injury as a result of hostile action, or noncombat, defined as injury resulting from nonhostile action. Injury mechanism was indicated on the EMED clinical record and was categorized into “blast” or “nonblast.” Loss of consciousness (LOC) information was available for 73.4 percent (83 of 113) of initial concussive events and 74.3 percent (84 of 113) of second concussive events.

Time Between Events

Time between events was calculated by subtracting the dates of injury for the first and second concussive event for each individual. This difference in injury dates was then used to establish three cutoff points in order to explore how time between events might be associated with injury severity and healthcare utilization. As per previous literature, the first and second cutoff points explored differences between those with concussive events that occurred (1) less than or equal to 2 weeks or greater than 2 weeks apart and (2) less than or equal to 3 months or greater than 3 months apart [21]. We used a third cutoff point, median time between events, in order to apportion comparison groups equally.

Severity of Second Injury

A variable was created to indicate whether the second concussive event was more severe than the first event according to the head AIS (i.e., head AIS increased from 1 to 2).

Healthcare Utilization

Because the most common symptoms after a concussion are cognitive (decreased memory, attention, and concentration), somatic (headache, fatigue, insomnia, dizziness, tinnitus, and sensitivity to noise or light), and affective (depression, irritability, and anxiety), utilization of mental health and neurology services was examined [22]. Utilization of mental health and neurology outpatient services was identified from the Standard Ambulatory Data Record (SADR) database. The SADR electronic database contains a Medical Expense and Performance Reporting System code for each outpatient visit, which indicates the type of clinic for each patient encounter.

It is standard practice for military personnel to be referred for a follow-up visit postinjury. To capture true utilization of healthcare due to continuing problems beyond the initial follow-up, we defined utilization as two or more visits to mental health (identified as psychology, psychiatry, mental health, or substance abuse) or neurology clinics within 24 months of the second concussion. Mental health and neurology utilization were examined separately. Personnel with more than two documented concussions (n = 6) were restricted from this analysis. Other types of healthcare utilization were examined for descriptive purposes and included primary care, general medicine/surgery, physical or occupational therapy, audiology, and other.

Data Analysis

All statistical analyses were performed using SPSS, version 17.0 (SPSS Inc; Chicago, Illinois). Comparisons between concussive events were conducted using Wilcoxon signed rank and McNemar tests for dependent samples. The association of time between events and increased severity at the second concussive event was assessed using chi-square and Fisher exact tests. Healthcare utilization was described by number of clinic visits in the first and second years following the second concussive event. Age-adjusted logistic regression analysis was used to examine the predictive effect of concussion severity and time between events on utilization of mental health and neurology outpatient services.

RESULTS

Demographic statistics for the study sample are summarized in **Table 1**. The study sample consisted of 113 servicemembers injured during deployment in Operation Iraqi Freedom. The median age was 21 years (range 18–39) and consisted primarily of Marines (92.0%). Overall, 94.7 percent (n = 107) experienced two concussive events and 5.3 percent (n = 6) experienced three or four. At the time of the first event, the majority were in infantry positions and junior enlisted.

Table 1.
Demographic characteristics of 113 servicemembers who sustained two or more concussions during deployment in Operation Iraqi Freedom.

Characteristic	Median (Range) or *n* (%)
Age (yr)	21 (18–39)
Rank	
Junior Enlisted	68 (60.2)
Midlevel Enlisted	35 (31.0)
Senior Enlisted	6 (5.3)
Officer/Warrant Officer	4 (3.5)
Service	
Marine Corps	104 (92.0)
Army	6 (5.3)
Navy	3 (2.7)
Occupation	
Infantry	76 (67.3)
Other/Unknown	37 (32.7)

Types of concussion at the first and second event are detailed in **Table 2**. Of those in which presence or absence of LOC could be confirmed, a majority did not experience LOC at either the first (57 of 83, 69%) or second (51 of 84, 61%) event. Overall, 68 individuals had confirmed presence or absence of LOC for both concussive events. Of these, more than half (14 of 23) who experienced LOC at their first event also experienced confirmed LOC at their second, compared with only 29 percent (13 of 45) of personnel without LOC at their first event, although this difference was not statistically significant (McNemar p-value = 0.52).

Results shown in **Table 3** compare injury-specific characteristics of the first and second concussive events. For both the first and second event, over 90 percent were combat-related and caused by blast mechanisms. No statistical differences were found between the first and second event by type and mechanism of injury or maximum head AIS and ISS. Overall, 16 percent (18 of 113) had an increase in head AIS at the second concussive event.

The median time between events was 40 days (range 2–753, interquartile range 20–75), with 19 percent (22 of 113) of repeated concussive events occurring within an interval of 2 weeks and 87 percent (98 of 113) occurring within 3 months. As shown in **Table 4**, the time between repeated concussive events at the median, 2-week, and 3-month intervals was not associated with an increase in head AIS from the first to second event.

Healthcare utilization for the 107 personnel with only two concussions is shown in **Table 5**. General medicine/surgery accounted for the largest proportion of healthcare visits in the first year following repeat concussion, while primary care visits accounted for the largest proportion in the second year. **Table 6** displays both unadjusted and adjusted results of the mental health and neurology utilization regression analysis. Utilization of mental health and neurology outpatient services was indicated for 17 percent (n = 18) and 33 percent (n = 35) of personnel, respectively. In age-adjusted logistic regression analysis, time between events was not associated with an increase in clinic utilization. Severity of second concussive event, however, was significantly associated with mental health (odds ratio [OR] = 4.74, 95% confidence interval [CI] = 1.52–14.75, p-value = 0.01) and neurology (OR = 3.41, 95% CI = 1.32–8.75, p-value = 0.01) clinic utilization. Results did not change after including severity of first event, severity of second event, time between events, and age together in one multivariable model.

Table 2.
Distribution of first and second concussive events by type (n = 113). Data reported as n (%).

First Concussion (ICD-9-CM code)	Second Concussion			
	No LOC	LOC ≤30 min	LOC, NOS	Concussion, NOS
No LOC (850.0)	32 (56.1)	12 (21.1)	1 (1.8)	12 (21.1)
LOC ≤30 min (850.11)	6 (33.3)	10 (55.6)	1 (5.6)	1 (5.6)
LOC, NOS (850.5)	3 (37.5)	2 (25.0)	1 (12.5)	2 (25.0)
Concussion, NOS (850.9)	10 (33.3)	6 (20.0)	0 (0.0)	14 (46.7)

Note: Percentages are calculated by row. Because of rounding, percentages may not total 100.
ICD-9-CM = International Classification of Diseases, 9th Revision, Clinical Modification; LOC = loss of consciousness; NOS = not otherwise specified.

Table 3.
Distribution of first and second concussive events by injury-specific characteristics (n = 113).

Characteristic	First Concussion	Second Concussion	p-Value
Combat Injury, n (%)	107 (94.7)	109 (96.5)	0.63*
Blast Mechanism, n (%)	105 (92.9)	107 (94.7)	0.73*
Severity Indicator			
ISS, Mean ± SD	2.5 ± 1.6	2.8 ± 2.1	0.46†
Head AIS, Mean ± SD	1.2 ± 0.4	1.3 ± 0.4	0.60†
Maximum Head AIS 2, n (%)	27 (23.9)	30 (26.6)	0.60*

*McNemar test.
†Wilcoxon signed rank test.
AIS = Abbreviated Injury Scale, ISS = Injury Severity Score, SD = standard deviation.

Table 4.
Effect of time between concussive events on severity of second concussion (n = 113).

Time Between Events	n	No. with Increased Head AIS	%	p-Value
Median*	57	11	19.3	0.32
>Median	56	7	12.5	
2 Weeks	22	2	9.1	0.52
>2 Weeks	91	16	17.6	
3 Months	98	16	16.3	>0.99†
>3 Months	15	2	13.3	

*Median was 40 days.
†Fisher exact test was used because of small cell sizes.

Table 5.
Healthcare utilization in 2 years following second concussive event (n = 107).

Type of Clinic	0–12 Months After 2nd Concussive Event		12–24 Months After 2nd Concussive Event	
	n	% of Visits	n	% of Visits
Primary Care	334	14.9	325	28.3
General Medicine/Surgery	663	29.7	231	20.1
Physical or Occupational Therapy	563	25.2	160	13.9
Mental Health	229	10.2	251	21.9
Neurology	167	7.5	69	6.0
Audiology	129	5.8	51	4.4
Other	150	6.7	61	5.3
Total Visits	2,235	100.0	1,148	100.0

DISCUSSION

Concussions are common among U.S. military personnel serving in Iraq and Afghanistan. Though multiple studies have detailed the occurrence of combat-related TBI, the present study extends the analysis to those with repeated concussive events. A key finding was the high proportion of repeated concussions that occurred within a short period of time, as high as 20 percent within 2 weeks and 87 percent within 3 months of the first event. One previous study among professional football players found repeated concussions occurred among 4 percent and 20 percent of the sample at 2 weeks and 3 months, respectively [21]. Another study in college football players found that 9 of 12 players who had within-season concussions experienced the repeat concussion within 1 week of the initial concussion [23]. Unfortunately, neither of these studies assessed the effect of time between concussions on concussion severity or healthcare utilization.

In our analysis, healthcare utilization was not statistically associated with severity of the initial concussive event. A statistically positive association was found, however, between increased severity of the second event and mental health and neurology clinic utilization. These findings suggest that the most recent concussive event, as opposed to cumulative effects of concussions, may be more predictive of subsequent healthcare utilization. Alternatively, comparing personnel with multiple concussions to personnel with a single concussive event may be more effective in elucidating any cumulative effects and should be a focus of future research. Because a recent policy change proposed by the Chairman of the Joint Chiefs of Staff would restrict personnel to noncombat duty following their third concussion, further research is needed on the effects of repeated concussions among combat veterans.* An extension of the present analysis to those servicemembers with one and more than two concussive events is warranted, in part to assess the public

*Zoroya G. Joint Chiefs Chairman seeks brain-injury limit [Internet]. McLean (VA): USA Today; 2009 [updated 2009 Sep 28; cited 2010 Jan 14]. Available from: http://www.usatoday.com/news/military/2009-09-27-brain-injury-limit_N.htm.

Table 6.
Age-adjusted associations from logistic regression modeling predictors of postinjury utilization of mental health and neurology outpatient services (n = 107).*

Characteristic	Mental Health			Neurology		
	OR	CI	*p*-Value	OR	CI	*p*-Value
Concussion Severity†						
First Event						
Unadjusted	0.87	0.26–2.92	0.82	1.12	0.44–2.84	0.81
Adjusted	0.87	0.26–2.92	0.82	1.12	0.44–2.85	0.81
Second Event						
Unadjusted	3.94	1.37–11.37	0.01	3.03	1.22–7.47	0.02
Adjusted	4.74	1.52–14.75	0.01	3.41	1.32–8.75	0.01
Time Between Events						
≤Median						
Unadjusted	0.60	0.21–1.67	0.33	0.67	0.30–1.51	0.34
Adjusted	0.59	0.21–1.67	0.32	0.67	0.30–1.51	0.33
≤2 Weeks						
Unadjusted	1.30	0.38–4.49	0.67	1.14	0.41–3.16	0.81
Adjusted	1.30	0.38–4.47	0.68	1.13	0.41–3.15	0.81
≤3 Months						
Unadjusted	3.17	0.39–25.87	0.28	2.13	0.56–8.11	0.27
Adjusted	3.31	0.40–27.17	0.26	2.20	0.57–8.46	0.25

*Individuals with >2 concussions were excluded (n = 6).
†Compared moderate concussion (Head AIS = 2) with mild concussion (Head AIS = 1).
AIS = Abbreviated Injury Scale, CI = confidence interval, OR = odds ratio.

health implications of a concussion-limit policy and also to more clearly define the effects of two concussions, a topic on which civilian studies have yielded mixed findings [14,24–26].

Little is known about the mediating effect of time between concussive events. The time interval between the first and second concussion in the present analysis did not statistically affect healthcare utilization following the second event. It should be noted, however, that those who experienced a repeat concussion less than 3 months after their initial concussion trended toward higher odds of utilizing mental health and neurology services, but the small sample size may have limited our ability to detect a statistical association. A recent study among professional football players found no association of time between repeat concussions and number of reported postconcussive symptoms [21]. Another study found similar results, though time between events was analyzed as a dichotomous variable of less than or greater than 6 months, which may have diluted any association [27]. One recent study found evidence of a mediating effect of time, but this study used electroencephalography to directly measure brain function [14]. The severity measure used in the present study (AIS) may not have been sensitive or specific enough to show an association, and healthcare utilization may be more a reflection of willingness to present for care. As indicated by the aforementioned research, a mediating effect of time may be better studied with neurological tests or rates of self-reported symptoms following the first and subsequent concussive events. More focused research may eventually lead to policies similar to the “return-to-play” guidelines implemented in high school and collegiate athletics [28].

The greatest strength of this study was the use of provider-diagnosed cases of concussion. Most similar studies rely on self-report information, which may be subject to recall bias. Additionally, the EMED data allowed for abstraction of injury dates, from which time between events was calculated. This capability is unique because accurate dates of injury for mild concussion may not be otherwise documented, particularly in such an austere environment. The ability to link EMED data with electronic medical databases also allowed for the examination of long-term healthcare utilization.

The primary limitation of this study was the small sample size. It is possible that the lack of a larger sample precluded significant findings. In addition, only personnel who reported to and were treated at Navy-Marine Corps facilities were included in the present analysis. As such, Marines were likely overrepresented in the sample, and untreated injuries or injuries treated at other facilities, such as U.S. Army Combat Support Hospitals, were not represented. In addition, information regarding LOC was often not indicated; thus missing data precluded any detailed assessment of this variable. Information related to the underlying cause of blast-related concussion, whether due to blast overpressure or resulting blunt trauma, was not available for analysis at the time of this study and may have affected results. Given adequate sample size, future research should incorporate a thorough assessment of the physical cause of concussion. Finally, although the healthcare utilization data were contingent on remaining in military service, results did not change when excluding personnel who were discharged from the military during the 2-year follow-up period ($n = 3$).

CONCLUSIONS

This is the one of the first reports of repeated concussion among military personnel in a combat-deployed setting. Although the relationship of time between events and health outcomes remains unclear, further study on the cumulative effects of multiple concussive events among military personnel is warranted and may be strengthened by a larger sample size, in addition to cognitive and neurological testing. Military personnel are at risk for repeated concussion. Detailed postconcussion outcome analysis and assessment is essential in order to improve overall well-being, maximize force readiness, and refine clinical management and treatment protocols.

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