



***The Effect of Armed Forces Qualification  
Test Score on Mental Health Outcome  
Following Mild Traumatic Brain Injury***

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Mild Traumatic Brain Injury

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**ABSTRACT**

Higher intelligence scores are protective against the development of psychological disorders and may also protect against brain injury-related cognitive decline. The objective of this study was to assess the relationship between preinjury intelligence and mental health outcomes among combat veterans with mild traumatic brain injury (MTBI). Military personnel injured in Iraq between 2004 and 2007 were identified from theater clinical records and grouped into MTBI ( $n = 1069$ ) and non-MTBI ( $n = 1911$ ). Preinjury intelligence was assessed using the Armed Forces Qualification Test (AFQT) score. A retrospective review was conducted to identify those with postinjury mental health disorders (ICD-9-CM codes 290–319). Those with MTBI had higher overall rates of mental health disorder compared with non-MTBI. In the MTBI group, AFQT score was lower among those with a mental health diagnosis after adjusting for covariates (adjusted mean AFQT 54.1 vs. 57.9,  $p < 0.01$ ). A similar association was not found in the non-MTBI group. Additional research should explore the utility of using preinjury intelligence to identify high-risk MTBI subgroups.

## INTRODUCTION

Mild traumatic brain injury (MTBI) is an emerging public health problem among U.S. military personnel deployed to Iraq and Afghanistan.<sup>1-5</sup> A recent RAND Corporation report found that approximately 19% of deployed military personnel may have experienced a brain injury event, with many of them not seeking treatment.<sup>6</sup> Mental disorders are a frequently reported outcome of MTBI, with multiple studies linking MTBI to depression, posttraumatic stress disorder (PTSD), and other anxiety disorders.<sup>7-12</sup>

Various studies in both military and nonmilitary samples have identified intelligence as a correlate of psychological outcomes.<sup>13-17</sup> Kremen et al. found that Vietnam veterans in the highest quartile of cognitive ability had a 48% lower risk of PTSD compared with the lowest quartile.<sup>13</sup> Similarly, in a civilian study, lower childhood intelligence quotient (IQ) was associated with increased risk of adult mental health disorders, such as depression and anxiety.<sup>14</sup>

The association between intelligence and mental health outcome has also been identified in patients with TBIs ranging from mild to severe.<sup>18-22</sup> Additionally, a recent study by Raymont et al. found that penetrating brain injury was independently associated with cognitive decline among Vietnam veterans.<sup>23</sup> Together, these studies suggest the relationship between intelligence and mental health outcome may be more robust in those with MTBI, because the injury itself may contribute to a further decline in cognitive ability. Such findings could provide clinicians with an important predictive variable for targeting interventions among those with MTBI.

The aim of the present study was to explore the relationship between preinjury intelligence and mental health outcomes among combat veterans with MTBI. Use of a non-MTBI comparison group addressed limitations of previous research. A standard measure of IQ used by the military—the Armed Forces Qualification Test (AFQT)—allowed for preinjury

assessment of intelligence. It was hypothesized that lower AFQT scores would be more strongly associated with adverse mental health outcomes among combat veterans with MTBI compared to those with other injuries.

## **METHODS**

### ***Study Sample***

A retrospective review of clinical records from the Expeditionary Medical Encounter Database (EMED, formerly the Navy-Marine Corps Combat Trauma Registry) was performed. The study sample consisted of 2980 personnel injured during combat operations in Iraq between 2004 and 2007. Personnel were identified from clinical records completed by providers and collected at forward-deployed medical facilities (i.e., U.S. military treatment facilities stationed in Iraq to treat casualties).<sup>24</sup> This study was approved by the Institutional Review Board at Naval Health Research Center, San Diego, CA.

### ***Measures***

Injuries were classified from the clinical records using the Abbreviated Injury Scale (AIS) and *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes.<sup>25,26</sup> The AIS details the severity of each injury in nine body regions and ranges from 1 (minor injury) to 6 (fatal injury). Injury Severity Score (ISS) is calculated using the AIS. The ISS represents the overall injury severity accounting for all injuries the patient suffered, and is scored in a range of 1 to 75.<sup>27</sup> Only personnel with an ISS of 1–8 were included in the present study, in order to reduce the contributing effect of other system injuries, and ISS was further categorized into minor (ISS 1–3) and moderate (ISS 4–8) injuries.<sup>28,29</sup> All MTBI patients had at least one ICD-9-CM code in the following ranges: 800.0–801.9, 803.0–804.9, or 850.0–854.1.<sup>30</sup>

All MTBI events were mild in severity as indicated by a maximum head AIS of 1 or 2.<sup>30</sup> The non-MTBI comparison group consisted of all minor and moderate injuries with no clinical documentation of MTBI.

Provider-diagnosed mental health disorders were abstracted from an electronic database of Standard Ambulatory Data Records (SADRs). A mental health diagnosis was indicated by presence of an ICD-9-CM code in the range of 290 to 319, excluding 305.1 (tobacco addiction), within 24 months postinjury. Mental health conditions included the following categories based on ICD-9-CM codes: mood disorders (296, 300.4, 301.13, 311), anxiety disorders (300.00–300.02, 300.21–300.29, 300.3, 308.3, 308.9, 309.81), adjustment disorders (309.0–309.9, excluding 309.81), substance abuse disorders (291, 292.0, 292.1, 292.3–292.9, 303, 304, 305.0, 305.2–305.7, 305.9), and other (any other code between 290 and 319 not previously listed). Previous mental health diagnosis was identified from the SADR database by the presence of a mental health ICD-9-CM code at any time before the injury date. Those with a previous mental health diagnosis were excluded from the analysis. We also excluded personnel in the non-MTBI group with a diagnosis of post-concussion disorder (ICD-9-CM 310.2), indicating this individual had a history of MTBI.

The AFQT score has been previously validated as a predictor of IQ and was used as a proxy for intelligence in this analysis.<sup>31</sup> The AFQT is part of the Armed Services Vocational Aptitude Battery (ASVAB), a preenlistment screening for enlisted personnel.<sup>32</sup> The ASVAB has an oversight group ensuring that it adheres to professional testing standards, and routine analyses are conducted to ensure the ASVAB is fair across racial/ethnic/gender groups.<sup>33</sup> The score is presented as a percentile, ranging from 31 (scores below require waivers) to 99. To allow for

waivers, AFQT scores as low as 21 were included in the analysis. The AFQT score has been used in recent research of the effects of military deployment on mental health outcomes.<sup>34-36</sup>

The demographic variables age, military rank, occupation, and branch of service were abstracted from the EMED clinical record and confirmed via military personnel databases. Age at the time of injury was classified as “8–24 years” and “25 years and older.” Military rank was categorized into junior enlisted (E1–E5) or higher (E6 or higher). Branch of service was dichotomized into Marines or other. Occupation was categorized into infantry and non-infantry as indicated by a military occupational specialty of “Infantry, General.”

### ***Data Analysis***

All statistical analyses were performed using SAS version 9.1 (SAS Institute Inc., Cary, NC). Demographic and injury-specific information was compared by injury status (MTBI or non-MTBI) using chi-square tests for categorical variables and two-tailed *t* tests for continuous variables. Rates of mental health diagnoses were compared across the MTBI and non-MTBI groups using chi-square tests. The crude mean AFQT score was compared using two-tailed *t* tests across groups after stratifying by presence/absence of a mental health diagnosis. An additional analysis was conducted using the least-squares means (LSMEANS) procedure in SAS to calculate and compare mean AFQT scores after adjusting for demographic and injury-specific covariates. All statistical tests used an alpha level of 0.05.

## **RESULTS**

The study sample consisted of 2980 personnel injured in combat operations in Iraq between 2004 and 2007. Of these, 35.9% ( $n = 1069$ ) were MTBI and 64.1% ( $n = 1911$ ) were non-MTBI. Table I outlines the military and demographic characteristics of the sample stratified

by MTBI status. Groups differed by branch of service; Marines composed a higher proportion of the MTBI than non-MTBI group (81.0% and 75.0%, respectively). Overall, moderately severe injury severity was more frequent among those with MTBI (37.5% vs. 21.0%,  $p < 0.01$ ). The MTBI group had a slightly higher percentage of persons in the 18–24 years age group (75.7% vs. 71.9%,  $p = 0.03$ ), was of more junior rank (92.3% vs. 89.0%,  $p < 0.01$ ), and was more likely to have been injured via blast (98.4% vs. 84.2%,  $p < 0.01$ ). There were no differences between groups with regards to AFQT score or infantry-related occupation. When comparing mean AFQT score by demographic and injury-specific covariates, only age and injury severity were statistically different (data not shown). Specifically, higher mean AFQT scores were found among military personnel aged 25 and older compared to 18–24 years (60.6 vs. 58.2,  $p < 0.01$ ), and among those with minor compared to moderate injuries (59.3 vs. 57.7,  $p = 0.04$ ).

Postinjury prevalence of mental health disorders are presented in Table 2. Overall, 31% of the MTBI group and 22% of the non-MTBI group were diagnosed with a mental health disorder within 24 months post injury ( $p < 0.01$ ). In the MTBI group, anxiety and other disorders (including post-concussion disorder) were most frequent (19% and 20%, respectively), and anxiety disorders accounted for the largest prevalence (14.8%) in the non-MTBI group. Service members with MTBI compared with non-MTBI had significantly higher rates of anxiety, mood, and other disorders, but similar rates of adjustment and substance abuse disorders.

Table 3 displays the mean AFQT scores for both the MTBI and non-MTBI groups stratified by mental health disorder status. In the MTBI group, those with a diagnosed mental health disorder had significantly lower crude means of AFQT than those not diagnosed with a mental health disorder (55.9 vs. 60.3,  $p < 0.01$ ). Mean AFQT score did not differ significantly by mental health diagnosis in the non-MTBI group. Results were consistent after comparing AFQT

means adjusted for age, military rank, branch of service, blast mechanism, infantry occupation, and injury severity. The adjusted AFQT means for those with mental health disorders were significantly lower compared to those without mental health disorders in the MTBI group (54.1 vs. 57.9,  $p < 0.01$ ) but not the non-MTBI group (57.5 vs. 58.8,  $p = 0.21$ ).

## DISCUSSION

The present study explores the relationship between intelligence, brain injury, and mental health outcome among combat-injured personnel. Preinjury intelligence was inversely associated with mental health diagnosis among those with MTBI, but not for those with other injuries. The primary finding of the study suggests that personnel with lower AFQT scores and who sustain a combat-related MTBI may be at increased risk for adverse mental health outcomes. This may have implications in the clinical setting in that AFQT score may be used to identify those at greater risk for poor outcome.

A possible mechanism for our primary finding is the cognitive reserve hypothesis, which suggests that higher intelligence (or more cognitive reserve) is an indicator of more efficient cognitive and neural processing and thus, may allow for more effective compensation following brain injury.<sup>37-39</sup> Otherwise stated, higher intelligence leads to a reduced risk of cognitive deficit following brain injury, which is a predictor of mental health morbidity.<sup>13-17</sup> This hypothesis may be one explanation for how patients with a similar severity of brain injury can develop varying degrees of outcomes.<sup>37</sup> A recent study among Vietnam veterans also had findings indicative of the cognitive reserve mechanism; in this study, Raymond et al. found that higher preinjury intelligence (measured by AFQT) was protective against later cognitive decline in veterans with a head injury, though not in an uninjured comparison group.<sup>23</sup>

Studies in concordance with the present results are also found in civilian populations. Dawson et al. found a relationship between IQ and duration of posttraumatic amnesia (PTA), an indicator of more severe head injury, among general trauma admissions for MTBI, in that those with lower IQ had longer duration of PTA.<sup>18</sup> Another study found a similar relationship between preinjury intelligence and incidence of depression, but was among only patients with moderate to severe head injury.<sup>19</sup> The results of the present study coupled with previous literature suggest that preinjury intelligence is an important indicator of mental health outcome following MTBI.

Secondary to the primary finding, we identified that the overall rate of mental health diagnoses postinjury was high, with 31% of MTBI and 22% of non-MTBI receiving at least one diagnosis. This is consistent with a recent study of Veterans Administration electronic records that found one in four combat veterans received a mental health diagnosis.<sup>40</sup> The large proportion of anxiety disorders was expected because deployed military personnel are a high-risk group for PTSD and other anxiety disorders.<sup>34</sup> Rates of mental health diagnosis were generally higher in the MTBI group compared to non-MTBI which is consistent with previous literature.<sup>7-12</sup>

The primary strengths of the present study were the use of an unbiased pre-injury intelligence measure and the use of an injured control group, thereby addressing the limitations of previous research. In addition, because the EMED contains records of injured personnel from far-forward levels of care, we were able to include personnel with minor injuries who were returned to duty and would otherwise not be identified in studies using databases with hospitalized or medically evacuated personnel only. Another strength of the present study is that we used provider-diagnosed cases of MTBI based on injury-specific information provided in proximity to the actual event, thus eliminating the effects of recall bias often associated with studies using self-report injury information.

There are limitations that warrant mention. The present study lacked a measure for combat exposure, which in at least one study has been shown to mediate the relationship between intelligence and mental health outcome.<sup>36</sup> Nevertheless, this likely did not greatly affect the results since all members of the study sample suffered a combat injury, indicating some level of combat exposure among all personnel. We also adjusted for infantry occupations which generally have higher rates of combat exposure. The primary outcome measures—mental health disorders—were ascertained from an electronic database that tracks medical encounters, which are contingent on the patient presenting for care. This may have led to an underestimate of psychological morbidity because of an aversion to seek treatment, or only the most severe cases presenting. Another concern was the inability to determine whether a service member was discharged, which may have led to incomplete follow-up as the SADR database contained only medical information up to military discharge.

## **CONCLUSIONS**

With the recent emergence of TBI during the current military conflicts in Iraq and Afghanistan, it has become increasingly important to identify those in need of clinical intervention. Because lower preinjury intelligence was found to be associated with the presence of mental health problems in veterans with MTBI, AFQT score may be a potentially valuable discriminator of clinical risk. Future studies should examine other adverse outcomes, such as decline in cognitive functioning, and should assess the effects of other deployment-related experiences, such as combat exposure. As MTBI continues to significantly burden deployed U.S. service members, identifying high-risk groups for early intervention is of increasing military and public health importance.

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**TABLE I.** Descriptive Statistics, MTBI vs. non-MTBI, Operation Iraqi Freedom, 2004–2007

Characteristic	MTBI		Non-MTBI		<i>p</i> value
	<i>(n</i> = 1069)		<i>(n</i> = 1911)		
Age-years, no. (%)					0.03
18–24	809	(75.7)	1376	(71.9)	
25 and older	260	(24.3)	536	(28.1)	
Rank, no. (%)					<0.01
E1–E5	987	(92.3)	1701	(89.0)	
E6 and higher	82	(7.7)	210	(11.0)	
Marines, no. (%)	866	(81.0)	1433	(75.0)	<0.01
AFQT, mean (SD)	58.9	(19.0)	58.8	(18.7)	0.90
Blast mechanism, no (%)	1052	(98.4)	1609	(84.2)	<0.01
Infantry occupation, no. (%)*	624	(59.0)	1093	(58.5)	0.78
Injury severity					<0.01
Minor	669	(62.5)	1511	(79.0)	
Moderate	401	(37.5)	401	(21.0)	

AFQT, Armed Forces Qualification Test; MH, mental health; ISS, injury severity score; SD, standard deviation.

\* *n* = 53 observations not included due to missing data.

**TABLE II.** Frequency of Mental Health Diagnoses, MTBI vs. non-MTBI, Operation Iraqi Freedom, 2004–2007

Diagnosis <sup>a</sup>	MTBI		Non-MTBI		<i>p</i> value
	( <i>n</i> = 1069)		( <i>n</i> = 1911)		
Anxiety disorder	202	18.9%	283	14.8%	<0.01
Mood disorder	88	8.2%	94	4.9%	<0.01
Substance abuse	54	5.1%	98	5.1%	0.93
Adjustment disorder	71	6.6%	119	6.2%	0.66
Other <sup>b</sup>	216	20.2%	109	5.7%	<0.01
Any MH diagnosis	337	31.5%	428	22.4%	<0.01

*Note.* Individuals may have multiple diagnoses. MH, mental health.

<sup>a</sup>Each category is calculated as a separate variable. <sup>b</sup>Includes postconcussion disorder.

**TABLE III.** Crude and adjusted mean Armed Forces Qualification Test scores by mild traumatic brain injury (MTBI) and mental health (MH) status ( $n = 2980$ ), Operation Iraqi Freedom, 2004–2007

Mean $\pm$ S.D.	Total			MTBI			Non-MTBI		
	MH+( $n = 765$ )	MH-( $n = 2215$ )	$p$ value	MH+ ( $n = 337$ )	MH- ( $n = 732$ )	$p$ value	MH+ ( $n = 428$ )	MH- ( $n = 1483$ )	$p$ value
Overall	56.9 $\pm$ 17.8	59.5 $\pm$ 19.1	<0.01	55.9 $\pm$ 18.7	60.3 $\pm$ 19.0	<0.01	57.8 $\pm$ 17.0	59.1 $\pm$ 19.1	0.18
Adjusted <sup>a</sup>	56.8	59.0	<0.01	54.1	57.9	<0.01	57.5	58.8	0.21

<sup>a</sup>Adjusted for age, military rank, branch of service, infantry occupation, and injury severity.

# REPORT DOCUMENTATION PAGE

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<b>14. ABSTRACT</b>
<p>Various studies in both military and nonmilitary samples have identified intelligence as a correlate of psychological outcomes. Higher intelligence scores are protective against the development of psychological disorders and may also protect against brain injury-related cognitive decline. The objective of this study was to assess the relationship between preinjury intelligence and mental health outcomes among combat veterans with mild traumatic brain injury (MTBI). Military personnel injured in Iraq between 2004 and 2007 were identified from theater clinical records and grouped into MTBI (<math>n = 1069</math>) and non-MTBI (<math>n = 1911</math>). Preinjury intelligence was assessed using the Armed Forces Qualification Test (AFQT) score. A retrospective review was conducted to identify those with postinjury mental health disorders (ICD-9-CM codes 290–319). Those with MTBI had higher overall rates of mental health disorder compared with non-MTBI. In the MTBI group, AFQT score was lower among those with a mental health diagnosis after adjusting for covariates (adjusted mean AFQT 54.1 vs. 57.9, <math>p &lt; 0.01</math>). A similar association was not found in the non-MTBI group. Additional research should explore the utility of using preinjury intelligence to identify high-risk MTBI sub-groups.</p>

<b>15. SUBJECT TERMS</b> mild traumatic brain injury, MTBI, Armed Forces Qualification Test, AFQT, mental health
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