Wechsler Adult Intelligence Scale-Third Edition Characteristics of a Military Traumatic Brain Injury Sample

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This article describes the postinjury cognitive functioning of a sample of active duty, retired, and military beneficiaries who received traumatic brain injuries. Patients were seen in the neuropsychology clinic at Brooke Army Medical Center for a detailed cognitive and personality assessment. The scores on a major component of this evaluation, the Wechsler Adult Intelligence Scale, third edition, are summarized. The results are compared with those reported in the Wechsler Adult Intelligence Scale, third edition technical manual for a smaller, less diverse sample. The findings are consistent with the formulation that stable verbal skills are most resistant to brain injury, followed by nonverbal reasoning and visuospatial ability, and then working memory with speed of information processing being the most vulnerable to the effects of brain injury.

Introduction

The incidence and characterization of individuals experiencing a traumatic brain injury (TBI) are of particular relevance to the military. Adolescent and young adult men are at increased risk for TBI, making the active duty military population a particularly vulnerable group.[1] TBI among active duty troops account for at least 14% of surviving war casualties and require a disproportionate amount of acute and long-term care resources (http://www.biausa.org/Pages/For%20Military%20%26%20Veterans.html).[2] The sequelae of severe brain injuries often lead to retirement and separation from the military on medical grounds. Even after mild TBI, subtle deficits in thinking and judgment can affect duty performance, rank advancement, and worldwide qualification status.

In the military setting, clinical neuropsychologists are responsible for cognitive evaluations of brain-injured patients. The Wechsler Intelligence Scales have long been a cornerstone of such evaluations. In 1997, the Wechsler Adult Intelligence Scale, third edition (WAIS-III), became available for use.[3] With the previous edition of the WAIS, neuropsychologists were able to determine verbal intelligence quotient (IQ), performance IQ, and subtest scores. In the newer WAIS-III, subtests are also grouped into four indexes based on factor analysis. Scores on these indexes would appear to provide the neuropsychologist with an opportunity for a finer-grained analysis of intellectual functioning after TBI. This study presents WAIS-III IQ, index, and subtest scores for 61 active duty and military health care beneficiaries who were referred to the neuropsychological service of a major military medical center subsequent to a TBI. Severity of the TBIs ranged from mild through severe. The relationship of these scores to the individual's demographic characteristics and severity of the brain injury is examined. These data supplement those presented in the WAIS-III technical manual for a small group ($N = 22$) of moderate to severe TBI cases.[4]

Methods

Patients

A retrospective chart review was conducted on 61 adult military service members and military dependents that received outpatient neuropsychological evaluation at Brooke Army Medical Center in San Antonio, Texas. The sample selected for study was composed of individuals evaluated between June 1998 and June 2001 with a primary diagnosis of TBI. The final sample of 61 was reached after excluding a few cases because of the presence of confounding diagnoses, such as anoxia and cerebrovascular disorders. Reasons for referral included assessment of reported deficits, documentation of cognitive impairments, evaluation for return to duty determination, and medical board review for military separation. Table I presents the sample characteristics on basic demographic variables.

The present group is more racially heterogeneous than the TBI standardization sample reported in the WAIS-III manual. Whereas the standardization sample was entirely Caucasian, the present sample is approximately 60% Caucasian, 20% African American, and 20% Hispanic and other. Consistent with the demographics of both TBI and military populations, the present sample included proportionately more men (88% compared with 64% in the standardization sample). Age and education are relatively equivalent for the standardization and present samples. It can be seen in Table I that over one-third of the sample was undergoing medical/physical evaluation board process at the time of evaluation. Approximately one-third was on temporary disability leave, and slightly less than one-third was serving on active duty.

As shown in Table II, compared with the clinical TBI standardization sample, the present sample was more heterogeneous in terms of severity of injury and time since injury. The standardization sample included only individuals who had an initial Glasgow Coma Scale score less than 13 and loss of consciousness of at least 60 minutes, excluding all mild TBI cases. The standardization sample was evaluated between 6 and 18 months after injury, whereas the present sample included cases evaluated from 1 to 204 months after injury. Over one-half of the present cases incurred TBI from a motor vehicle accident. Other major causes of TBI in the current sample included falls and assaults, each accounting for 15% to 20% of the injuries.

Procedure

Demographic and injury information were collected at the time of the neuropsychological evaluation from medical records

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TABLE I

DEMOGRAPHIC/DESCRIPTIVE DATA FOR THE SAMPLE

Parameters	N	%	Mean ± SD	Range
Sex				
Male	54	88.5		
Female	7	11.5		
Race				
Caucasian	36	59.0		
African American	12	19.7		
Hispanic	11	18.0		
Other	2	3.2		
Military status				
Active duty	16	26.2		
Dependent	2	3.3		
Under board review	23	37.7		
Temporary disability leave	20	32.8		
Employment				
Active duty	39	63.9		
Unemployed	16	26.2		
Unknown	1	1.6		
Employed	5	8.2		
Handedness				
Left	9	14.8		
Right	52	85.2		
Age (years)			28.4 ± 8.0	18–57
Years of education			12.8 ± 1.6	10–18

$N = 61$.

TABLE II

INJURY DATA FOR THE SAMPLE

Parameters	N	%
Severity		
Mild	22	36.1
Moderate	20	32.8
Severe	19	31.1
Cause		
Assault	9	14.8
Blow/explosion	1	1.6
Fall	10	16.4
Motor vehicle accident	35	57.4
Pedestrian vs. vehicle	3	4.9
Sports	3	4.9

$N = 61$. The mean ± SD for time since injury was 33.9 ± 37.8 months with a range of 1 to 204 months.

and interviews with the participant and, when possible, a family member. Classification of severity of TBI as mild, moderate, or severe was determined using available medical record information. Mild TBI cases had loss of consciousness less than 60 minutes and no neurological findings. Cases with loss of consciousness between 1 and 24 hours or significant neurological findings, even if the loss of consciousness was somewhat less than 60 minutes, were classified as moderate. Severe cases were those hospitalized for several days or longer with documented neurological damage and prolonged recovery.

The WAIS-III was administered and scored according to standard procedures by either a psychologist in postdoctoral fellowship training or a trained neuropsychological technician. WAIS-III scores analyzed in this study included age-corrected scaled scores on 13 subscales (omitting the Optional Object Assembly Subtest), four index scores (Verbal Comprehension Index [VCI], Perceptual Organization Index [POI], Working Memory Index [WMI], and Processing Speed Index [PSI]), and three IQ scores (full-scale, verbal [VIQ], and performance [PIQ]). Statistical comparison between VIQ and PIQ scores was done using a within-subjects Student's *t* test. Comparisons among the four index scores were made using an overall one-way within-subjects analysis of variance followed by individual pairwise comparisons using within-subjects Student's *t* test.

Results

Table III presents summary statistics for WAIS-III scores. No evidence of global impairment of IQ scores was seen for the sample as a whole. Average VIQ score of 103.6 was significantly higher than the average PIQ score of 99.6 ($t = 2.72$; $df = 60$; $p = 0.008$). The four mean WAIS-III index scores differed significantly ($F = 18.86$; $df = 3$; $p < 0.001$). Index scores show the expected pattern, with the lowest performance occurring on the PSI. Pairwise Student's *t* test revealed that PSI scores were significantly lower than the other three index scores (VCI, $t = 7.20$, $df = 60$, $p < 0.001$; POI, $t = 5.65$, $df = 60$, $p < 0.001$; WMI, $t = 3.56$, $df = 60$, $p = 0.001$). WMI scores were significantly lower than VCI ($t = 3.33$; $df = 60$; $p = 0.001$) and POI ($t = 2.27$; $df = 60$; $p = 0.03$) scores. Looking at the individual subscale scores, it can be seen that the best performances occurred on comprehension and vocabulary subtests, and by far the weakest result occurred on the digit symbol subtest. The average scaled score on the digit symbol subtest of 8.0 was 1 entire score unit below the next highest subscale mean score of 9.0 on the symbol search subtest. The combination of these two subtests, digit

TABLE III

WAIS-III IQ, INDEX, AND SUBSCALE SCORES FOR THE SAMPLE

WAIS-III	Mean ± SD	Range
IQ scores		
Full-scale IQ	102.3 ± 14.4	74–145
VIQ	103.6 ± 14.8	79–140
PIQ	99.6 ± 14.2	70–144
Index scores		
VCI	103.2 ± 14.5	78–140
POI	100.9 ± 13.3	72–138
WMI	97.6 ± 13.6	67–133
PSI	91.8 ± 14.9	68–134
Subscale scores (age-corrected)		
Vocabulary	11.0 ± 2.9	4–17
Similarities	10.6 ± 3.6	4–17
Arithmetic	9.7 ± 2.6	3–14
Digit span	10.1 ± 3.2	4–17
Information	10.2 ± 2.7	5–17
Comprehension	11.9 ± 3.1	6–18
Letter-number sequencing	9.3 ± 2.5	3–15
Picture completion	9.9 ± 3.3	4–18
Digit symbol	8.0 ± 3.0	2–17
Block design	10.3 ± 2.6	5–19
Matrix reasoning	10.4 ± 2.9	1–17
Picture arrangement	10.8 ± 3.2	1–17
Symbol search	9.0 ± 3.1	3–19

$N = 61$.

symbol and symbol search, comprise the PSI, which collectively account for the weak scores on this index compared with the other three indexes.

Table IV presents WAIS-III IQ and index scores separately for mild, moderate, and severe TBI groups. Age-corrected scaled scores on WAIS-III subscales for mild, moderate, and severe TBI groups are shown in Table V. WAIS-III scores for the three severity groups are quite similar. Because of small sample sizes within the severity subgroups, statistical comparisons of WAIS-III scores across groups were not possible.

Discussion

The findings of this study suggest that the revisions seen in the WAIS-III can enhance its value as a neuropsychological instrument in a TBI population. In particular, the four WAIS-III indexes provide a finer-grained analysis of cognitive functioning than do the VIQ and PIQ scores in themselves. In this study, there was a statistically significant difference between VIQ and PIQ scores, although the actual means differed by only approximately 4 points. Traditionally, the VIQ has been considered a measure of stable verbal skills, whereas the PIQ as an indicator of fluid reasoning skills has been thought to be more vulnerable to brain injury.[5] This assumption has recently been questioned in a review of 10 studies that found VIQ to be only slightly higher than PIQ in TBI populations.[6] Although present findings reveal a statistically significant difference between VIQ and PIQ scores, the difference was clinically modest. These findings support the view that PIQ is more vulnerable to brain injury than VIQ but with variability across patients and clinically small overall group differences.

The WAIS-III verbal subtests can be looked at in terms of the VCI and the WMI as opposed to a monolithic VIQ. Similarly, the

TABLE IV

WAIS-III IQ AND INDEX SCORES FOR MILD, MODERATE, AND SEVERE TBI GROUPS

WAIS-III	Mean ± SD	Range
Full-scale IQ		
Mild	103.8 ± 14.1	79–135
Moderate	105.4 ± 15.7	75–145
Severe	97.16 ± 12.6	74–120
VIQ		
Mild	104.7 ± 16.0	82–140
Moderate	106.6 ± 14.6	79–138
Severe	99.2 ± 13.2	79–133
PIQ		
Mild	100.6 ± 13.2	79–128
Moderate	103.0 ± 15.8	75–144
Severe	95.1 ± 13.3	70–121
VCI		
Mild	105.4 ± 17.0	80–140
Moderate	104.5 ± 12.9	78–129
Severe	99.4 ± 13.0	80–129
POI		
Mild	101.1 ± 10.9	78–118
Moderate	103.1 ± 15.9	72–138
Severe	98.3 ± 13.0	72–120
WMI		
Mild	95.7 ± 11.6	71–117
Moderate	101.1 ± 15.9	75–133
Severe	96.2 ± 13.0	67–117
PSI		
Mild	93.6 ± 16.1	68–134
Moderate	94.7 ± 16.1	69–134
Severe	86.5 ± 10.9	69–111

TABLE V

WAIS-III SUBSCALE AGE-CORRECTED SCALE SCORES FOR MILD, MODERATE, AND SEVERE TBI GROUPS

WAIS-III	Mean ± SD	Range
Vocabulary		
Mild	11.4 ± 3.2	7–17
Moderate	11.5 ± 3.1	4–17
Severe	10.0 ± 2.3	7–15
Similarities		
Mild	10.7 ± 4.1	4–17
Moderate	11.0 ± 3.6	4–17
Severe	10.0 ± 3.1	5–17
Arithmetic		
Mild	9.6 ± 2.4	5–14
Moderate	9.8 ± 2.8	4–14
Severe	9.5 ± 2.7	3–14
Digit span		
Mild	9.5 ± 2.7	5–16
Moderate	11.4 ± 3.9	4–17
Severe	9.5 ± 2.9	6–16
Information		
Mild	10.8 ± 3.1	6–17
Moderate	10.1 ± 1.8	7–14
Severe	9.7 ± 2.9	5–15
Comprehension		
Mild	12.5 ± 3.3	7–18
Moderate	12.3 ± 2.9	7–17
Severe	10.9 ± 3.0	6–18
Letter number sequencing		
Mild	9.0 ± 2.1	4–12
Moderate	9.5 ± 2.7	3–15
Severe	9.3 ± 2.7	3–13
Picture completion		
Mild	10.1 ± 3.2	5–15
Moderate	10.0 ± 3.6	4–15
Severe	9.6 ± 3.2	4–18
Digit symbol		
Mild	8.4 ± 3.4	4–17
Moderate	8.4 ± 3.2	2–14
Severe	7.1 ± 2.1	4–11
Block design		
Mild	10.0 ± 2.3	5–14
Moderate	11.0 ± 3.1	5–19
Severe	10.1 ± 2.3	7–14
Matrix reasoning		
Mild	10.4 ± 3.2	1–17
Moderate	10.8 ± 2.8	5–16
Severe	10.0 ± 2.8	4–15
Picture arrangement		
Mild	11.2 ± 3.8	1–17
Moderate	11.4 ± 3.1	7–17
Severe	9.8 ± 2.4	5–13
Symbol search		
Mild	9.4 ± 3.2	3–19
Moderate	9.8 ± 3.3	5–18
Severe	7.9 ± 2.6	3–14

performance subtests can be broken down into the POI and PSI. In the current sample, the VCI had the highest mean score, followed by the POI, the WMI, and the PSI. These findings are consistent with the formulation that stable verbal skills are most resistant to brain injury, followed closely by nonverbal reasoning and visuospatial ability, and then working memory with speed of information processing being the most vulnerable to the effects of brain injury. In terms of subtest scores, digit symbol appears to be most sensitive to the effects of TBI.

Prior research suggests that the WAIS-III PSI score is a sensitive indicator of cognitive function. Lower PSI scores characterized all clinical groups in the standardization samples of the WAIS-III.[7] In a study using profile analysis with WAIS-III index scores, subgroups were formed based on both overall level of WAIS-III performance and on a pattern of scores represented primarily by low or high score on the PSI.[8] Another recent study found a large effect size of PSI score when comparing mild TBI, moderate-severe TBI, and control groups.[9] TBI patients in another study showed slowing on the WAIS-III digit symbol subtest (one of the two major subtests loading on the PSI) at 1-week after injury compared with patients with mild non-neurological injuries.[10] Taken together, all of these results support the idea that processing speed is a sensitive indicator of global brain function and efficiency after TBI.

Not only is processing speed often poorer than other cognitive functions after TBI, but there is also evidence suggesting that its recovery is prolonged. In a study developing a mathematical model for recovery from TBI based on duration of coma and WAIS-R scores, PIQ, a major component of which is processing speed, was over four times slower to recover than VIQ.[11] Present results reinforce this concept in that our sample was tested an average of almost 3 years after injury, yet PSI scores were significantly lower than scores on the other WAIS-III indexes. In summary, present results indicate that global intelligence is relatively unaffected after TBI. They reinforce prevailing research showing that speed of information processing is particularly vulnerable to brain injury across a range of severity and time after injury.

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