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COPEMAN HEALTHCARE CENTRE

Comparing Patients with Mild Traumatic Brain Injury to Trauma Controls on CNS Vital Signs

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Objective: To compare performance on a computerized neuropsychological test battery, CNS Vital Signs (CNS-VS), in a sample of patients with mild traumatic brain injury (MTBI) and trauma controls.

Design: Quasi-Experimental, Two-Group, Between-Subjects Design.

Participants: Participants were 50 patients who met the WHO Collaborating Center Task Force criteria for MTBI and 31 orthopedically-injured trauma control subjects. Groups were similar in age, years of education, and estimated intellectual ability. A substantial minority (28%) of the MTBI group had a trauma-related abnormality on day-of-injury CT (i.e., a "complicated MTBI").

Setting: Participants were recruited from the Emergency Department of Vancouver General Hospital.

Main Outcome Measure: The CNS-VS, which generates a Neurocognition Index (NCI) and five primary domain scores, was administered approximately 6-8 weeks post injury.

Results: Differences in mean performance were examined with a MANOVA. Differences in the frequency of low scores at four cutoffs (1SD, $<10^{th}$ %ile, $\leq 5^{th}$ %ile, and <2SDs) were compared using chi-square analyses. There was no significant difference between groups for the NCI. A MANOVA using the five domain scores did not reveal statistically significant differences between the groups. Moreover, there were no group differences on any of the domain scores on exploratory ANOVAs. The frequencies of low scores at each cutoff, although more common in the MTBI sample, were not statistically different.

Conclusions: Participants with MTBI did not differ on computerized testing when compared to trauma control subjects 6-8 weeks following injury. A greater number of patients with MTBIs had low scores, but the differences between groups were not statistically significant.

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Background: Computerized cognitive screening is an efficient method of measuring cognitive functioning and is increasingly being used in clinical practice and research. CNS Vital Signs (CNS-VS; Gualtieri & Johnson, 2006), a computerized cognitive screening battery, has been used with multiple clinical populations (Brooks & Sherman, 2012; Iverson, Brooks, Langenecker, & Young, 2011; Iverson, Brooks, & Young, 2009). However, only one study has investigated performance on CNS-VS in patients with traumatic brain injury (Gualtieri & Johnson, 2008). The purpose of this study was to compare performance on CNS-VS in a sample of patients with mild traumatic brain injury (MTBI) and trauma controls.

Methods: Participants were 50 patients who met the WHO Collaborating Center Task Force criteria for MTBI and 31 orthopedic trauma control subjects. Participants were recruited from the Emergency Department of Vancouver General Hospital.

Groups were similar in age, years of education, and estimated intellectual ability. A substantial minority (28%) of the MTBI group had a trauma-related abnormality on day-of-injury CT (i.e., a "complicated MTBI"). See Table 1 for demographic characteristics of the groups. See Table 2 for clinical characteristics of the MTBI group.

Participants were administered the CNS Vital Signs battery approximately 6-8 weeks post injury. CNS-VS is comprised of seven common neuropsychological measures, including verbal and visual memory, finger tapping, symbol digit coding, a Stroop test, a shifting attention test, and a continuous performance test. The original battery generates 15 primary scores, which are used to calculate five domain (index) scores: Memory, Psychomotor Speed, Reaction Time, Cognitive Flexibility, and Complex Attention. A Neurocognitive Index score is also generated.

Table 1. Demographic Characteristics of the Groups.

	Mild TBI	Trauma Controls	t test (p-value)
Mean Age (*SD*)	30.1 (9.1)	34.4 (11.1)	-1.78 (0.08)
Age Range	19-55	19-55	
Mean Education (*SD*)	14.5 (2.3)	14.7 (2.7)	-0.41 (0.69)
Education range	11-22	12-23	
Male: Female	39:11	25:6	0.28 (0.78)
Mean RIST Index (*SD*)	109.0 (10.0)	105.9 (12.0)	1.26 (0.21)
Mean WTAR Standard Score (*SD*)	111.4 (10.9)	110.3 (9.9)	0.47 (0.64)

Levene's test for equality of variances was significant for age (p=.05). On independent t-tests, there were no significant differences between groups on the other demographic variables. The groups did not differ on level of estimated intellectual ability.

Table 2. Clinical Characteristics of the Mild TBI Group

	N	*%*
Mild TBI Classification		
Complicated	14	28.0
Uncomplicated	35	2.0
Mild - No CT	1	2.0
Mechanism of Injury		
MVA	19	38.0
Non-MVA	31	62.0
Day of Injury BAL		
Intoxicated (≥21 mmol/L)	26	52.0
Sober (<21 mmol/L)	24	48.0
Loss of Consciousness		
Positive	29	58.0
Negative	3	6.0
Equivocal	16	32.0
Not Stated	2	4.0
Glasgow Coma Scale		
15	21	42.0
13-14	29	58.0
Post-Traumatic Amnesia		
Positive	50	100.0
Negative	0	0.0

Abbreviations: BAL, blood alcohol level; CT, computerized tomography; MVA, motor vehicle accident.
Table Notes: For MTBI classification, injuries were considered complicated if there was an abnormality on CT. LOC presence or absence was obtained from chart review. Equivocal LOC was defined as a period of LOC that was unable to be confidently confirmed due to discrepant ambulance and hospital records, or the patient reported a period of LOC that was not substantiated by a witness.

Results: There was no significant difference on the Neurocognition Index (NCI) based on a univariate ANOVA. MANOVA was used to examine group differences on the five CNS-VS primary domains scores. Box's M test was significant, indicating that the covariance matrices differed (p=.015). In most cases, MANOVA is robust to modest violations to the assumptions of the general linear model. Results were thus interpreted. MANOVA, with the five cognitive domain scores as dependent variables and group membership as an independent variable, revealed no overall significant effect [$F(5,75) = .418$, $p = .835$, observed power = .154]. Given low observed power for the group comparisons, individual effect sizes between groups were also examined. The effect sizes were uniformly small to extremely small.

Table 3. CNS-VS Test Performance in the Mild TBI and Trauma Control Groups.

	Mild TBI (N=50)		Trauma Controls (N=31)		p	Cohen's d
	M	*SD*	*M*	*SD*		
Neurocognition Index Standard Score	98.3	14.7	100.9	14.8	0.450	0.17
Memory Standard Score	97.1	13.4	99.9	16.6	0.418	0.19
Psychomotor Speed Standard Score	103.1	15.5	102.3	18.4	0.847	0.05
Reaction Time Standard Score	99.5	13.6	100.8	13.5	0.650	0.10
Complex Attention Standard Score	94.9	21.3	99.3	18.4	0.354	0.21
Cognitive Flexibility Standard Score	101.9	22.1	103.0	20.2	0.529	0.05

Comparison of the prevalence of the number of low scores was undertaken by considering all 5 primary domain scores simultaneously. The cumulative percentages of the number of low scores at four cutoffs (1SD, <10th %ile, ≤5th %ile, and <2SDs) by group are presented in Table 4. The prevalence of low scores was similar between groups at each cutoff but low scores were generally more common in the MTBI group, although not statistically significant using chi-square analyses. Having two or more scores below 1SD was more common in the MTBI group (26.0%) than in the trauma control group (12.9%) [χ^2 (1) =1.98, p =.159; Odds Ratio=2.37 (95% confidence interval =.62 - 9.77)]. Having two or more low scores below the 10th percentile occurred in 20.0% of those with MTBIs and 6.5% of trauma controls [χ^2 (1) = 2.78, p = .095; Odds Ratio = 3.62 (95% confidence interval .66 = 26.02)]. Similarly, having one or more scores below two SDs was more common for MTBI (18.0%) than trauma controls (6.5%).

Discussion: There were no statistically significant differences between patients with MTBIs and trauma control subjects on CNS Vital Signs at 6-8 weeks post injury. This is consistent with meta-analytical studies reporting good neuropsychological outcome from MTBI at 1-3 months post injury (Belanger, Curtiss, Demery, Lebowitz, & Vanderploeg, 2005; Frencham, Fox, & Maybery, 2005; Rohling et al., 2011; Schretlen & Shapiro, 2003). At the individual level, a greater number of patients with MTBIs had low scores on CNS-VS, but the differences between groups were not statistically significant (in large part due to relatively small sample sizes).

Table 4. Base Rates of Low CNS-VS Domain Scores in Mild TBI, Trauma Controls, and another sample of Healthy Controls.

Number of Low Scores	Mild TBI (N=50)	Trauma Controls (N=31)	Healthy Controls[1] (N=659)
< 1 SD			
Zero Below Cutoff	56.0	67.7	59.0
1 or More Below Cutoff	44.0	32.3	41.0
2 or More Below Cutoff	26.0	12.9	18.2
3 or More Below Cutoff	10.0	--	7.7
4 or More Below Cutoff	4.0	--	2.1
5 or More Below Cutoff	0.0	3.2	0.6

[1] The data from the healthy control subjects are from: Iverson, G.L., Brooks, B.L., Langenecker, S.A., Young, A.H. (2011). Identifying a cognitive impairment subgroup in adults with mood disorders. *Journal of Affective Disorders, 132(3),* 360-367.

Number of Low Scores	Mild TBI (*N*=50)	Trauma Controls (*N*=31)	Healthy Controls[1] (*N*=659)
< 10th %ile			
Zero Below Cutoff	68.0	74.2	68.0
1 or More Below Cutoff	32.0	25.8	32.0
2 or More Below Cutoff	20.0	6.5	12.0
3 or More Below Cutoff	6.0	--	4.1
4 or More Below Cutoff	2.0	--	0.9
5 or More Below Cutoff	0.0	3.2	--
≤ 5th %ile			
Zero Below Cutoff	72.0	80.6	77.2
1 or More Below Cutoff	28.0	19.4	22.8
2 or More Below Cutoff	8.0	--	8.2
3 or More Below Cutoff	4.0	--	1.8
4 or More Below Cutoff	2.0	--	0.3
5 or More Below Cutoff	0.0	3.2	--
< 2 SDs			
Zero Below Cutoff	82.0	93.5	89.5
1 or More Below Cutoff	18.0	6.5	10.5
2 or More Below Cutoff	8.0	--	2.7
3 or More Below Cutoff	0.0	--	0.3
4 or More Below Cutoff	0.0	3.2	--

Table Note: Values represent cumulative percentages.

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