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Ecological validity of the neuropsychological assessment battery screening module in post-acute brain injury rehabilitation

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Abstract

Primary objective—To assess the ecological validity of the Screening Module of the Neuropsychological Assessment Battery (NAB-SM) using the Functional Independence Measure (FIM).

Method—Seventy individuals with moderate-to-severe traumatic brain injury at a residential post-acute rehabilitation facility were administered the FIM instrument and the NAB-SM upon admission. Hierarchical regression analysis was used to examine the relationship between the variables from these two assessment measures.

Results—Hierarchical models revealed that (1) the NAB-SM Total score was significantly associated with the FIM instrument Total score as well as the Motor and Cognition sub-scale scores, above and beyond the contribution of demographic variables, (2) the NAB-SM Language, Memory and Spatial domain scores were significantly associated with of the FIM instrument Cognition sub-scale score and (3) the NAB-SM Spatial domain score was significantly associated with of the FIM instrument Total and Motor sub-scale scores.

Conclusions—The current findings support previous research and provide strong evidence for the ecological validity of the NAB-SM with regard to functional abilities as assessed by the FIM instrument.

Keywords

Traumatic brain injury; neuropsychological assessment; outcomes assessment; rehabilitation

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Introduction

Cognitive impairment secondary to traumatic brain injury (TBI) can greatly limit an individual's functional independence. The assessment of cognitive impairment via the administration and subsequent interpretation of a comprehensive neuropsychological test battery is paramount in the rehabilitation setting as a means to aid in treatment planning. Within a comprehensive rehabilitation setting each discipline (e.g. Neuropsychology, Occupational Therapy, Physical Therapy and Speech/Language Pathology) may utilize various assessment measures in order to gauge a patient's cognitive status upon admission. While these assessment measures are purported to assess a wide range of skills it is crucial for them to maintain some degree of ecological validity in order to provide consistent and reliable information about a patient's cognitive abilities to the interdisciplinary treatment team.

The relationship between measures of functional skills and measures of neuropsychological ability in the brain-injured population has been extensively assessed. By functional skills, one means essential activities of daily life (ADL) such as dressing, grooming, feeding, swallowing, functional mobility, home management, transitions and transfers, bathing, toileting and other life skills. The Uniform Data System for Medical Rehabilitation (UDS_{MR}) is the largest non-governmental medical rehabilitation outcome dataset [1,2]. The core of UDS_{MR} is the Functional Independence Measure (FIM™) [3] that is widely used in assessing functional status in individuals with disabilities. (The FIM™ instrument is a trademark of Uniform Data System for Medical Rehabilitation, a division of UB Foundation Activities, Inc.) The FIM instrument consists of 18 items, 13 of which assess basic ADL (eating, grooming, bathing, dressing upper body, dressing lower body, toileting, bladder management, bowel training, bed/chair/wheelchair transfer, toilet transfer, tub/shower transfer, walk/wheelchair and stairs), with the remaining five items that assess cognitive skills (comprehension, expression, social interaction, problem-solving and memory).

Research work assessing the relation between the FIM instrument and measures of neuropsychological functioning is varied. Smith-Knapp et al. [4] administered measures of neuropsychological ability and functional skills to 164 patients with TBI. The authors discovered that select measures from the Halstead-Reitan Neuropsychological Test Battery (HRNTB) [5] and the Wechsler Adult Intelligence Scale-Revised (WAIS-R) [6], as well as injury-related variables were related to motor and cognitive performances as assessed by the FIM instrument. In their study, Smith-Knapp et al. [4] reported that four variables from the HRNTB (each with a motor component), as well as length of stay (in days) at a residential brain injury rehabilitation programme were found to account for 39% of the variance for the FIM instrument Motor score. Alternatively, the Comprehension sub-test from the WAIS-R (a measure that assesses reasoning skills with regard to everyday problems, social issues and proverbs), number of days in residential rehabilitation and performance on a test of finger oscillation (using the dominant hand) from the HRNTB accounted for 29% of the variance for the FIM instrument Cognitive score. Further, it was discovered that the WAIS-R Comprehension sub-test alone accounted for 20% of the variance, which led the authors to posit that the FIM instrument Cognitive score does assess its intended construct (i.e. social cognition). In a similar vein, Hajek et al. [7] administered various functional, neurological, physical and neuropsychological measures to a sample of 66 stroke patients. Their analysis of correlation coefficients did not yield any statistically significant relationships between neuropsychological (e.g. Stroke Unit Mental Status Examination [SUMSE] [8]; Raven coloured progressive matrices [9], Boston Naming Test [BNT] [10]; and Mini Mental State Examination [MMSE]) [11] and functional (e.g. FIM instrument, Barthel Index [12] and the Rankin Functional Scale [13]) measures, whereas clear relationships were noted between the latter and both physical (e.g. Clinical Outcomes Variables Scale [14] and Stages of Motor Recovery Test [15,16]) and neurological (e.g. Canadian Neurological Scale [17] and National

Institute of Health Stroke Scale [15]) measures. On an exploratory basis, Hajek et al. [7] performed correlational analyses solely with the FIM instrument Cognitive score and the aforementioned neuropsychological measures. The FIM instrument Cognitive score was significantly, although moderately, associated with the SUMSE, BNT and the MMSE. Furthermore, the authors conducted a principal components factor analysis that yielded a 3-factor solution that included (1) a physical disability factor, (2) a cognitive disability factor and (3) a dementia factor. Functional measures (including the FIM instrument Total score) loaded onto the physical disability factor, but not the cognitive disability or dementia factors. Fong et al. [18] administered the FIM instrument and the Chinese version of the Neurobehavioural Cognitive Status Examination (NCSE) [19] to a sample of 37 stroke patients upon admission to a residential brain injury rehabilitation setting. Six out of the nine sub-tests from the NCSE (Orientation, Comprehension, Construction, Repetition, Calculation and Judgement) were significantly, although weakly-to-moderately correlated (0.30–0.48) with the FIM instrument Motor score. The authors did not administer the cognitive portion of the FIM instrument. Kutlay et al. [20] reported on the relationship between performances on the Middlesex Elderly Assessment of Mental State (MEAMS) [21] and the FIM instrument in 155 brain-injured patients in a post-acute rehabilitation setting. The FIM instrument Cognitive scale and the MEAMS total score demonstrated a moderate relationship at admission (0.571, $p < 0.001$), whereas a weak relationship was discovered between the FIM instrument Motor scale and the MEAMS total score at admission (0.187, $p < 0.05$).

The variable findings reported between performances on the FIM instrument (Motor and Cognition) and select neuropsychological measures in the aforementioned studies may be attributed, in part, to characteristics of the neuropsychological tests or test batteries utilized. Neuropsychological test batteries such as the HRNTB, although quite comprehensive with standardized normative data, can be lengthy to administer (i.e. >4 hours) and may not be well tolerated by patients with TBI who may be experiencing fatigue, pain, attentional difficulties and/or psychological distress. Alternatively, brief cognitive measures or mental status exams such as the MMSE can have very high false negative rates [22] and may not be suitable to accurately assess patients with extremely low or high levels of functioning. Furthermore, these brief measures may not comprehensively address all cognitive domains (e.g. attention, language, visuospatial, memory and executive).

The current study assessed the relationship between all portions of the FIM instrument with the screening module from the Neuropsychological Assessment Battery (NAB) [23] in a sample of patients with TBI in a residential post-acute rehabilitation setting. The NAB is a newly published comprehensive neuropsychological test battery that incorporates six modules (Attention, Language, Memory, Spatial, Executive and a Screening module). To date, there have been few published studies on the NAB [24,25] or the NAB screening module [26–28] using neurological patient samples.

The screening module from the NAB-SM mirrors the full NAB in that it assesses five cognitive domains: (a) an Attention domain measured by orientation, digit span (forward and backward) and letter cancellation; (b) a Language domain measured by auditory comprehension and confrontation naming; (c) a Memory domain measured by immediate and delayed story recall and immediate and delayed shape recognition; (d) a Spatial domain measured by visual form discrimination and two-dimensional construction of pictured designs; and (e) an Executive domain measured by speeded word generation and speeded visuomotor maze navigation. The NAB-SM has several characteristics that are favourable for assessing cognition in a residential brain injury rehabilitation setting. First, the NAB-SM can be administered in less than 1 hour. Second, index scores for each domain, as well as a Total NAB Screening score, are standardized and are presented as *T*-scores. Demographically corrected norms are based on age, education level and gender. Third, the screening module, as well as the remaining modules of the full

NAB, has two parallel forms that are ideal for repeat testing (e.g. admission vs. discharge). A complete delineation of the NAB is provided elsewhere [23,29].

Method

Participants

The sample consisted of 70 individuals (57 males, 13 females) consecutively admitted to a residential rehabilitation programme with a history of moderate-to-severe TBI, as defined by a Glasgow Coma Scale score between 3–12, loss of consciousness greater than 30 minutes and positive neuroimaging findings. Mean age of the sample was 36.0 (SD = 13.6) and mean educational attainment was 12.1 years (SD = 2.2). The racial breakdown of the sample was 47 Caucasian, 14 Hispanic, eight African-American and one Asian. The mean interval between injury and current admission was 1.7 years (SD = 4.0 years).

Procedure

All participants were administered the FIM instrument within 72 hours of their admission. Variables used in the analysis included: (1) the FIM instrument Total Score, (2) the FIM instrument Cognitive Sub-total Score and (3) the FIM instrument Motor Sub-total Score.

The NAB-SM was administered to all participants a mean of 7.8 days from their admission (SD = 6.6). Demographically corrected standard scores were used in all cases. NAB-SM variables included: (1) the Total NAB Screening Standard Score and (2) standard scores for each of the NAB Screening Cognitive Domains (Attention, Language, Memory, Spatial and Executive). Administration adhered to standardized procedures as outlined in the testing manual.

Data analysis

The relationship between several potential demographic covariates (age, sex, race and time since injury) and the FIM instrument Total score, the FIM instrument Motor Sub-total Score and the FIM instrument Cognitive Sub-total Score were analysed using linear regression analysis. A significant relationship was observed between age and the FIM instrument Motor Sub-total score, $F(1, 63) = 4.29$, $p < 0.05$. A marginal relationship was found between sex and the FIM instrument Motor Sub-total Score, $F(1, 63) = 3.46$, $p = 0.07$. Age and sex were also marginally associated with the FIM instrument Total Score (Fs > 3.9, ps = 0.07). None of the potential covariates was associated with the FIM instrument Cognitive Sub-total Score. Thus, age and sex were added into the regression analyses as covariates to account for extraneous error variance.

Hierarchical regression analysis was used to examine the relationship between the variables from the NAB-SM and the FIM instrument. Age and sex were added into the first block and either the Total NAB Screening Standard Score or the five NAB Screening Cognitive Domain variables were added in the second block of the regression equations. For the models examining the independent contribution of the cognitive domain variables, unique (i.e. Type-3) sums of squares were analysed.

Results

Descriptive statistics for all relevant FIM instrument and NAB-SM variables are presented in Table I.

Hierarchical models regressing FIM instrument total score and motor and cognitive sub-totals on the NAB total screening standard score

Age and sex were significantly associated with the FIM instrument Total Score, $F(2, 67) = 3.87$, $p < 0.03$, adjusted $R^2 = 0.08$. The NAB Total Screening Standard Score significantly incremented the R^2, $F(1, 66) = 27.8$, $p < 0.0001$, adjusted $R^2\Delta = 0.26$. These demographic variables were significantly associated with the FIM instrument Motor Sub-total Score, $F(2, 67) = 3.93$, $p < 0.03$, adjusted $R^2 = 0.08$. The NAB Total Screening Standard Score was significantly associated with motor skills above the influence of age and sex, $F(1, 66) = 9.9$, $p < 0.003$, adjusted $R^2\Delta = 0.11$. Age and sex were not associated with the FIM instrument Cognitive Sub-total (adjusted $R^2 = 0$). The NAB Total Screening Standard Score was significantly associated with the FIM instrument Cognitive Sub-total score, $F(1, 66) = 77.0$, $p < 0.0001$, adjusted $R^2\Delta = 0.53$.

Hierarchical models regressing FIM instrument total score and motor and cognitive sub-totals on NAB screening cognitive domain scores

NAB-SM domain scores significantly incremented the association between the FIM instrument Total Score, the FIM instrument Motor and the FIM instrument Cognitive Sub-total Scores (Fs > 4.6; ps < 0.002). Analysis of individual domain parameter estimates revealed that the NAB-SM Spatial Domain score was independently associated with the FIM instrument Total Score, $t(1, 62) = 3.3$, $p < 0.002$, and the FIM instrument Motor Subtotal score, $t(1, 62) = 2.7$, $p < 0.009$. The NAB-SM Language, Memory and Spatial Domain Scores were all significantly and independently associated with the FIM instrument Cognitive Sub-total Score (all ts > 2.5, ps < 0.02).

Discussion

Previous research has demonstrated the relationship between measures of neuropsychological function and measures of functional independence. The purpose of the current study was to explore the ecological validity of a relatively new neuropsychological screening battery (NAB-SM) with an established measure of functional independence (FIM instrument) in a sample of individuals with moderate-to-severe TBI. The results of this study provide strong evidence for the ecological validity of the NAB-SM with regards to functional abilities. The NAB Total Screening score accounted for 26% of the variance in the FIM instrument Total Score, 11% of the variance in the FIM instrument Motor Sub-total score and 53% of the variance in the FIM instrument Cognitive Sub-total score. This was above and beyond the variability accounted for by demographic variables (i.e. age and sex).

Analysis of the independent contributions of the NAB-SM Cognitive Domain scores revealed that the NAB-SM Spatial domain was independently associated with both the FIM instrument Total Score and the Motor Sub-total. Given the obvious role of spatial analysis in many tasks assessed by certain FIM instrument Motor domains (e.g. locomotion, transfers and self-care tasks), these findings provide evidence for the ecological validity of the NAB-SM with regards to visuomotor functional activities. These results are consistent with those of Smith-Knapp et al. [4], who demonstrated a strong relationship between the FIM instrument Motor score and neuropsychological measures with a considerable motor component.

The NAB-SM Spatial domain score is derived by performance on two tasks: a visual discrimination task and a task involving the construction of designs using two-dimensional geometric pieces. There is no obvious similarity between these tests and ‘real-world’ functional tasks that would account for these strong relationships discovered in the current study. Rather, it may be the case that it is the underlying construct measured by these sub-tests that is associated with functional independence. Further research is needed to determine the

relationship between the NAB-SM Spatial domain and functional independence with various neurological populations.

Significant relationships were also observed between the NAB-SM and FIM instrument cognitive domains. NAB-SM Language, Memory and Spatial Domain scores were all independently associated with the FIM instrument Cognitive Subtotal score. These findings are consistent with other studies demonstrating a relationship between neuropsychological test performance and the FIM instrument [4,7].

No significant relationships were observed between the NAB-SM Attention domain and any of the FIM instrument scores. The reason for this lack of an independent relationship is unclear and subject to speculation. The NAB-SM Attention domain is comprised of forward and backward digit span tasks (measures of auditory attentional capacity and verbal working memory, respectively) and two letter cancellation tasks, which assess processing speed, visual scanning and selective and divided attention. Although similar zero-order correlations were observed for NAB-SM Attention as other NAB-SM domains, perhaps the variance in FIM instrument scores accounted for by NAB-SM Attention overlaps with the other NAB-SM domain scores. An alternative explanation relates to the properties of the second cancellation task that is purported to measure divided attention. Zgaljardic and Temple [28] reported that accuracy on the addition portion of this task, which is not accounted for in any scores, varies inversely with the efficiency score that is derived. Thus, failure or inability to attend sufficiently to one half of the divided attention task can result in an artificially inflated score and the perception of superior performance. Future studies can further articulate the relative contributions of the various components of the NAB-SM Attention domain to other cognitive and functional domains.

There are several limitations to the current study, which limit generalizability of the results. First, the sample consisted of individuals (mostly male) in post-acute rehabilitation from a TBI. It is unclear to what extent the current results generalize to other clinical populations. Replication of the current study in individuals with other neurological conditions (e.g. stroke) would be helpful in this regard. Second, the current results do not inform the ability of the NAB-SM to predict progress in rehabilitation from TBI. Longitudinal studies assessing functional progress across length of stay in rehabilitation are required to answer this empirical question. Third, the current study only demonstrates relationships between the NAB-SM and FIM instrument ratings. Future research can examine the relationship between the NAB-SM and observations or ratings made by other disciplines. Despite these limitations, the current study adds to the literature by demonstrating the ecological validity of the NAB-SM with regards to ratings of functional independence on the FIM instrument.

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Table I

Descriptive data for FIM and NAB-SM instrument variables.

Variable		Mean	SD	Minimum	Maximum
FIM	Total score	103.0	15.9	40	124
	Motor skills sub-total	79.6	13.9	28	91
	Cognitive skills sub-total	23.4	4.7	12	34
	Self care	35.8	6.3	14	42
	Sphincter control	13.3	2.0	4	14
	Mobility	18.5	3.8	3	21
	Locomotion	12.0	2.8	2	14
	Communication	10.3	2.2	6	14
	Social cognition	13.0	3.0	4	20
	Comprehension	5.2	1.1	3	7
	Expression	5.1	1.2	3	7
	Social interaction	4.7	1.2	1	7
	Problem-solving	4.3	1.0	2	6
	Memory	4.0	1.2	1	7
NAB-SM	Total screening standard score	74.2	16.6	49	116
	Attention	70.9	17.3	48	111
	Language	84.7	23.6	45	130
	Memory	86.7	15.6	56	132
	Spatial	85.9	16.3	53	122
	Executive	81.8	16.9	45	114