[Primary Care]   (CEU)

The Relationship Between Initial Physical Examination Findings and Failure on Objective Validity Testing During Neuropsychological Evaluation After Pediatric Mild Traumatic Brain Injury

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Background: The symptomatology after mild traumatic brain injury (mTBI) is complex as symptoms are subjective and nonspecific. It is important to differentiate symptoms as neurologically based or caused by noninjury factors. Symptom exaggeration has been found to influence postinjury presentation, and objective validity tests are used to help differentiate these cases. This study examines how concussed patients seen for initial medical workup may present with noncredible effort during follow-up neuropsychological examination and identifies physical findings during evaluation that best predict noncredible performance.

Hypothesis: A portion of pediatric patients will demonstrate noncredible effort during neuropsychological testing after mTBI, predicted by failure of certain vestibular and cognitive tests during initial examination.

Study Design: Retrospective cohort.

Level of Evidence: Level 4.

Methods: Participants (n = 80) underwent evaluation by a sports medicine physician ≤3 months from injury, were subsequently seen for a neuropsychological examination, and completed the Medical Symptom Validity Test (MSVT). Variables included results of a mental status examination (orientation), serial 7s examination, Romberg test, and heel-to-toe walking test. The primary outcome variable of interest was pass/fail of the MSVT.

Results: Of the participants, 51% were male and 49% were female. Eighteen of 80 (23%) failed the MSVT. Based on univariable logistic regression analysis, the outcomes of the Romberg test ($P = 0.0037$) and heel-to-toe walking test ($P = 0.0066$) were identified as significant independent predictors of MSVT failure. In a multivariable model, outcome of Romberg test was the only significant predictor of MSVT failure. The probability of MSVT failure was 66.7% (95% CI, 33.3% to 88.9%) when a subject failed the Romberg test.

Conclusion: A meaningful percentage of pediatric subjects present evidence of noncredible performance during neuropsychological examination after mTBI. Initial examination findings in some cases may represent symptom exaggeration.

Keywords: mild traumatic brain injury; pediatric; symptom validity testing; sports medicine

Between 1.6 and 3.2 million traumatic brain injuries (TBIs) occur in the United States each year. Annually, almost 500,000 TBI-related emergency department visits are made by children younger than 14 years.[8] For high school athletes, it is estimated that concussions occur at a rate of 2.5 per 10,000 athlete-exposures during competition and practice.[30] These reports may significantly underestimate the true incidence of mild TBI (mTBI), as many individuals who suffer such an injury do not present for medical attention.[24,32]

Although the majority of studies with school-aged youth have found that a single, uncomplicated mTBI results in postconcussive problems that resolve within days or weeks,[1,4,29,33] symptoms may persist in a minority of children.[34,39] The etiology of persistent symptomatology is complex as the symptoms of mTBI are subjective and nonspecific, and some symptoms, such as fatigue and headache, are commonly endorsed by healthy individuals without history of mTBI.[32,37,38] Understanding symptoms as neurologically based or as caused by nonneurologic or noninjury factors has clear implications for clinical decision making and management.

One factor that influences symptom presentation in adult neuropsychological studies is whether a patient is exaggerating symptomatology or malingering.[5] Objective validity tests have been utilized for decades in adult neuropsychological practice to help differentiate those patients who are responding validly from those who may be feigning impairment.[15] These tests are designed to appear difficult but in actuality are quite easy and can be performed well with very little effort or ability.[25] In fact, many studies have shown that validity test performance is not related to neurologic status or injury,[2,6,11,28] intellectual disability,[12] or acute and chronic pain.[7,17] Therefore, when patients perform poorly on these tests, a nonneurologic or noninjury explanation for the low scores should be explored.[3]

In studies with a variety of adult cases (personal injury, disability, criminal, medical), rates of malingering after mTBI in adults have been reported to be 40% or greater.[26,35] This has significant meaning because approximately 50% of the variance in neuropsychological ability–based test performance is accounted for by whether examinees exert adequate effort as measured by validity tests.[5,13,23] In a previous study of a similar case series, nearly 40% of the ability-based variance was accounted for by validity test performance in children after mTBI,[22] supporting the idea that some of the cognitive effects that are attributed to pediatric mTBI in clinical and research contexts are likely better explained by noncredible effort.

Historically, validity tests have not been used as frequently in child populations, likely because children have been viewed as lacking the sophistication needed to deceive providers and because children often lack clear external incentives to feign (eg, monetary gain). Nevertheless, multiple single case reports have now documented clearly that children can feign cognitive impairment.[9,16,21,27,31] Several recent clinical neuropsychological case series have also found that a small percentage of general pediatric patients consistently perform noncredibly because of effort-related problems.[2,6,28] An ongoing case series from our group has documented that 15% to 20% of patients with mTBI presenting for clinical neuropsychological examination provide noncredible effort.[2,6,18-20,28] When individuals do not provide adequate effort during examination or exaggerate problems after mTBI, all data from the examination become suspect.[13,22,23]

Symptom underrepresentation and masking is a recognized problem in athletic populations.[36] While the risk of preemptive return to play is serious, it is also important for providers to be able to identify the subset of patients who feign symptoms, and therefore, require different clinical management. If symptom exaggeration is not considered as a possible explanation for problems after mTBI, providers are apt to misinterpret "postconcussive" symptoms in some cases. Clinical decisions may result in inappropriate or unnecessary interventions (eg, restriction from play, neuroimaging, specialty medical consultation, pharmacologic treatment, academic accommodations).

No identified study has examined whether children seen by sports medicine providers soon after injury might be exaggerating symptomatology after mTBI. The purpose of this study was 2-fold: (1) to examine how many concussed patients who are seen for sports medicine workup present with evidence of noncredible effort during a follow-up neuropsychological examination and (2) to identify physical findings during the initial medical evaluation that predict those children who fail validity testing during subsequent neuropsychological workup.

METHODS

The study used a retrospective cohort design. After institutional review board approval, participants were identified through a consecutive case search of an outpatient hospital-based concussion program. Participants were included if they underwent initial evaluation by a board-certified sports medicine physician within 3 months of a medically diagnosed mTBI and were subsequently seen for neuropsychological examination by a board-certified clinical neuropsychologist. All participants were between the ages of 8 and 18 years at the time of the neuropsychological evaluation. Children who had intracranial pathology on neuroimaging were included if their Glasgow Coma Scale (GCS) score was never less than 13. Exclusionary criteria for the study were: forensic referral, neurosurgical intervention, injury resulting from abuse, and nontraumatic brain injury such as hypoxia, stroke, or infectious illness.

Variables related to the participants' demographics, past medical histories, clinical evaluations, and circumstances surrounding their mTBI were collected at the time of the clinical visit. Demographic variables included age, sex, race, age at time of injury, parental education level (defined as follows: both parents achieved a 4-year college degree or higher, 1 parent achieved a 4-year college degree or higher, or neither parent achieved a 4-year college degree), history of child psychiatric disorder (eg, depression, anxiety, bipolar disorder, obsessive compulsive disorder, oppositional defiant/conduct disorder, and/or other psychiatric diagnosis), and neurodevelopmental/

neurologic disorder (eg, attention deficit/hyperactivity disorder, learning disability, autism spectrum disorder, seizure disorder). Variables related to the circumstances surrounding the mTBI included whether the participant lost consciousness and/or displayed retrograde or posttraumatic amnesia, time from the injury to the initial sports medicine evaluation, and whether the mTBI occurred during an organized sport. The primary sports medicine examination variables of interest included the results of the following clinical evaluations/tests that were dichotomized as pass or fail: a brief mental status examination that included orientation, serial 7s examination, WORLD spelled backward test, reverse calendar months examination, Romberg test, heel-to-toe walking test, and strength testing. Tests administered varied to some extent by clinical need and patients' abilities.

For the Romberg test, the patient was asked to stand straight up with their feet together and their eyes closed for 30 seconds. A failure was defined as poor balance and/or a step out of position during the evaluation time period. The heel-to-toe walking test was walking in a tandem gait touching the heel of one foot to the toe of the contralateral foot. A failure of the heel-to-toe walking test was defined as any observed abnormality of gait or evidence of unsteadiness. A failure of orientation was an inability to orient to all 3: person, place, and time. A delay of more than 5 seconds between responses or >1 inaccurate response was considered a failure of the serial 7s examination. Strength testing was measured by using the standard scale of 1/5 to 5/5, with <5/5 throughout all upper and lower extremities being abnormal. All participants underwent neuropsychological evaluation no earlier than 1 week and no later than 52 weeks postinjury.

The Medical Symptom Validity Test (MSVT) was administered to all participants undergoing neuropsychological evaluation and was used as the primary outcome variable of interest.[14] The MSVT consists of 3 primary indices of effort: immediate recognition, delayed recognition, and consistency. Examinees are presented with 10 semantically related word pairs twice on a computer screen. Immediately and after a brief delay, they are asked to choose the correct word from pairs consisting of the target word and a foil receiving both auditory and visual feedback regarding the accuracy of their response. Examinees are then asked to recall the words in paired associate and free recall conditions. Actuarial criteria proposed by Green[10] were considered indicative of noncredible effort. The MSVT has been validated for use in school-age children.[22]

Descriptive statistics were used to summarize the demographics and clinical characteristics of all participants included in the cohort. Univariable logistic regression analyses were used to identify variables related to the outcome of the MSVT. Variables significant at the alpha level of 0.15 were entered into the multivariable model. Prior to building the final model, a diagnostic analysis was used to evaluate pairwise measures of association between potential predictor variables. Among pairs of related variables, only 1 was chosen for inclusion in the model. A backward selection strategy was then used to remove nonsignificant variables from the multivariable

model. Only variables significant at the alpha level of 0.05 were included in the final multivariable model. Based on variables that were significant in the final model, the probability and corresponding 95% CIs of a failed MSVT were calculated.

RESULTS

A total of 80 participants (Table 1) were included in the final cohort (51.25% male, 48.75% female). The mean age of all participants was 14.23 ± 2.07 years at the time of their initial injury. All participants had a recent history of mTBI, and 31 reported a history of previous mTBI. The majority of participants (n = 51, 68%) sought medical attention for their

Table 1. Demographics and clinical characteristics

	n	%
Race		
White	55	68.8
Black	5	6.3
Asian	1	1.3
Unknown	15	18.8
Other	4	5.0
Parent education level		
Neither parent college	15	18.8
One college level	24	30.0
Both college level	41	51.3
History of psychiatric disorders		
No	66	82.5
Yes	14	17.5
History of neurodevelopmental disorder		
No	64	80.0
Yes	16	20.0
Loss of consciousness after mTBI		
No	57	76.0
Yes	18	24.0
mTBI occurred during organized sports		
No	33	41.3
Yes	47	58.8
Retrograde and/or postinjury amnesia		
No	48	60.0
Yes	32	40.0

mTBI, mild traumatic brain injury.

Table 2. Sports medicine evaluation results for participants passing and failing the MSVT

	Passed MSVT		Failed MSVT	
	n	%	n	%
Romberg test				
Normal	53	82.8	11	17.2
Abnormal	3	33.3	6	66.7
Heel-to-toe walking test				
Normal	45	83.3	9	16.7
Abnormal	4	40.0	6	60.0
Strength				
Normal	56	75.7	18	24.3
Abnormal	1	1.0	0	0.0
Orientation				
Normal	61	79.2	16	20.8
Abnormal	1	33.3	2	66.7
Serial 7s examination				
Normal	34	79.1	9	20.9
Abnormal	16	72.7	6	27.3

MSVT, Medical Symptom Validity Test.

Table 3. Point estimates for variables significantly ($P < 0.05$) associated with an MSVT failure in the univariable analysis

	OR	Lower CI	Upper CI	P Value
Romberg test				
Abnormal vs normal Romberg	9.64	2.09	44.52	0.0037
Heel-to-toe walking test				
Abnormal vs normal gait	7.50	1.75	32.09	0.0066

MSVT, Medical Symptom Validity Test; OR, odds ratio.

recent mTBI within 1 day of injury. The average time from injury to sports medicine evaluation was 17 days. Eighteen of 80 participants (23%) failed the MSVT. The average time from injury to neuropsychological examination was 51 days.

Associated injury findings were identified in 3 participants (2%) and included fractured and/or dislocated vertebrae (n = 2) and small foci of hemosiderin at the gray matter–white matter interface (n = 1). Abnormal radiographic, magnetic resonance imaging, and/or computed tomography findings were not identified in any participants who failed the MSVT (Table 2).

Factors Related to a Failed MSVT

Based on the univariable logistic regression analysis, the outcome of the Romberg test ($P < 0.01$), the outcome of the heel-to-toe walking test ($P < 0.01$), an mTBI that occurred during participation in an organized sport ($P = 0.06$), the outcome of failure of orientation ($P = 0.11$), and age at time of injury ($P = 0.11$) were considered for inclusion in the multivariable model (Table 3).

All variables significant at the alpha level of 0.15 were then considered for inclusion in the multivariable model. Because of

the high degree of correlation that existed between the outcome of the Romberg test and the outcome of the heel-to-toe walking test (Spearman $r = 0.80$), only the Romberg test was included in the multivariable analysis. The Romberg test was selected for inclusion in the multivariable model because it was identified as a stronger predictor of a failed MSVT in the univariable analysis than the heel-to-toe walking test ($P = 0.0037$ vs $P = 0.0066$) and because this variable was associated with a fewer number of missing data points. Using a backward selection strategy, the outcome of the Romberg test was identified as the only variable significantly related to the outcome of the performance validity test in the final multivariable model. The estimated probability of a MSVT failure was 67% (95% CI, 33.34% to 88.89%) for a subject that failed the Romberg test. In contrast, the estimated probability of a MSVT failure was 17.19% (95% CI, 9.78% to 28.44%) for a subject that did not fail the Romberg test.

DISCUSSION

Though given scant attention historically, the current study supports the idea that some meaningful percentage of children and adolescents may demonstrate evidence of symptom exaggeration and noncredible performance during examination after mTBI. In this clinical case series, 23% of children failed a well-validated performance validity test during neuropsychological evaluation.

This study did not focus on the classification accuracy of the MSVT or attempt to estimate the base rate of noncredible effort by determining the rate of false positives. The question of why children exert noncredible effort during a neuropsychological evaluation was also not the focus of this study. The neuropsychologists evaluating the study participants judged the reasons to be quite varied and to include both conscious and unconscious processes and attempts to obtain external gains (eg, additional support at school) and to fulfill internal psychological needs (eg, as seen in somatoform disorders). The Romberg test was identified as the strongest predictor of the outcome of the MSVT.

The true value of these findings is that they link the initial physical examination findings during medical examination to passage or failure of an objective validity test in follow-up neuropsychological evaluation. This helps highlight that at least some initial physical findings in a minority of patients presenting for medical examination after mTBI are likely explained by symptom exaggeration or feigning, as shown by failure of the symptom validity test. The science of validity testing is quite well established in the field of neuropsychology,[15] and the inclusion of validity measures should be routine practice in both pediatric and adult neuropsychological evaluations after mTBI.

The current study is characterized by several limitations. The length of time between initial physical examination and the neuropsychological consultation in which the MSVT was administered varied between 1 and 52 weeks among patients. We were also unable to control for individual experiences, such

as medical and nonmedical interventions, that may have occurred between the sports medicine and neuropsychological consultations.

Several clinical tests from the initial physical examination were not included in the univariable logistic regression analysis because of missing data and/or the absence of any cases where the subject failed both the MSVT and the clinical test of interest (see Table 2). These included the rapid hand-alternating movement test, finger-to-nose test, gaze stability test, convergence and accommodation test, reverse calendar months test, number reiteration in reverse test, and the WORLD spelled backward test. The Balance Error Scoring System (BESS) test was sporadically utilized by providers, and inclusion of the foam pad testing portion was rare; therefore, BESS test scores were not evaluated as part of the analysis.

CONCLUSION

This study demonstrates that initial physical examination findings in some cases are likely to represent symptom exaggeration or feigning. Clinical management that takes into account these potentially important noninjury factors will result in more targeted treatment and better care of these complex patients.

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