Automated Cerebral Assessment: An effective screening tool for mild TBI

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Abstract

Mild traumatic brain injury (mTBI) is the most prevalent form of brain injury in the United States. It is often the case that people who have experienced mTBI experience persistent cognitive deficits although there is a body of research that suggests that full recovery is expected within 3 months. Subtle cognitive deficits may persist but are not detectible with standard neuropsychological measures. Recently an FDA approved neurocognitive assessment device sensitive to the occurrence of subtle cognitive impairment in the elderly has been developed (Cognivue). The Cognivue device is considered an early detection assessment for dementia. In view of the presence of subtle deficits in people with mild TBI it was hypothesized that the Cognivue automated cerebral assessment system may be able to determine the presence of cognitive impairments that standard neuropsychological tests may miss or produce ambiguous results. People with mTBI were compared to normals on all subtests offered by Cognivue. All subtests were significantly weaker in the mTBI group than normal suggesting that Cognivue is very sensitive to subtle cognitive impairment in patients with persistent complaints of cognitive difficuoty following concussion.

Introduction

Mild TBI/concussion continues to be at the center of a debate regarding assessment approaches as well as whether this type of injury actually causes persistent cognitive impairments. Iverson (2005) illustrated that moderate and severe brain injuries have a pronounced negative effect on cognitive functioning, but mild TBI's (mTBI) have essentially no measurable effect on cognitive functioning after the acute recovery period. In other words, mTBI subjects one to three months postinjury were found to have essentially normal cognitive functioning using standard neuropsychological measures. Generalizations have been made that suggest that individuals who continue to complain of cognitive impairment following the acute recovery phase are either malingering, exaggerating or suffering from unrelated impairments. It is further assumed that if a person with mTBI scores normally on neuropsychological testing that he/she is therefore normal, in spite of complaints to the contrary. It is not uncommon for a patient to perform normally on standard neuropsychological measures despite complaints of cognitive difficulty. Some resolve this dilemma by trusting the test results as a true reflection of a normal cognitive state. This opinion does not have good "ecological" validity in most cases, since the patient and usually the spouse is, in fact, complaining of cognitive difficulty and the quality of the patient's life has not returned to normal. Generalizing on the basis of meta analyses that mTBI cognitive impairment does not exist after 3 months post-injury relies on a premise that mTBI is a homogeneous condition. More recent research suggests that mTBI is a heterogeneous phenomenon and each individual has a unique profile that contributes to the occurrence of cognitive difficulty (some of which cannot be measured with current neuropsychological procedures). It is clear that methods of assessment of cognitive complaints must change.

In the 1970's there was a debate regarding the long-term impact of alcohol use on cognitive functioning. Many studies indicated the absence of long-term cognitive impairment. Following a series of investigations conducted by Butters & Cermak, they demonstrated the lack of consistency in the literature was due to poor sensitivity of the neuropsychological tests utilized. Recently, in the area of mild cognitive impairment (MCI) it has been demonstrated that patients who complain of cognitive changes in spite of the presence of normal neuropsychological test results (Stage 1 Alzheimer's—asymptomatic), actually demonstrated impairment when the neuropsychological assessment utilized a non-standard "challenge" task that allowed the examiner to evaluate vulnerability to proactive and retroactive forms of interference.

The use of more sensitive measures of cognitive functioning is also needed to determine the presence or absence of cognitive impairment in various diagnostic groups such as: addiction, metabolic disorders, chronic pain, renal disease to name a few. In the addiction field, for example, over 35% of admissions to either outpatient or inpatient programs have a history of head injury/concussion. A sensitive screening method can be useful in identifying such patients. It has been demonstrated that taking into account the presence of cognitive impairment and adjusting treatment methods contributes to long-term success when treating addiction.

The use of cognitive screening methods for determining the presence of cognitive impairment in patients with a history of recent concussion (diagnosed in the emergency department following injury) have been limited to measures of varying sensitivity and type.

Standardized mental status examinations have been a poor method of screening while computer-based methods have been difficult to administer and interpret. Recently, an automated cerebral assessment technique was developed for the objective detection of cognitive and functional impairment in people above the age of 55. The measure (Cognivue) is the first computerized cognitive assessment device given FDA clearance and is stated to be a method of detection of cognitive impairment that may signal the early phases of progressive dementia. Failure on cognivue in people over the age of 55 successfully predicts functional decline.

Cognivue was created to provide healthcare practitioners with rapid, quantitative assessments of an individual's cerebral function. Cognivue is related to psychophysics in that it engages an individual in continuous stimulus-response paradigms that demand intervening cerebrocortical processes. Cognivue technology is a non-invasive and non-intrusive computerized assessment device. The viability of Cognivue in detection of cognitive difficulty related to dementia has been supported by a number of investigations. In view of its sensitivity with very early cognitive change in patients who eventually go on to develop dementia it was thought that Cognivue could possibly be a sensitive screening measure of cognitive impairment and function in people diagnosed with mTBI, who are complaining of cognitive difficulty despite being greater than 12 months post-injury.

In this investigation mTBI patients referred for neuropsychological evaluation who had a documented concussion, at least 12 months or greater prior to the referral, were hypothesized to demonstrate impairment on Cognivue as compared to normal controls. The average number of months since the injury was over one year (14 months).

Methods

Subjects

Subjects for this investigation were individuals referred for neuropsychological evaluation who had a formal diagnosis of post-concussion syndrome (mTBI) for a period of time not less than 12 months. Normal Control subjects were healthy volunteers with no history of neurological trauma or disease and no history of ADHD, LD or or any chronic systemic illness. Subjects with mTBI who failed symptom validity testing were eliminated from the analysis.

The mTBI subjects and normal control subjects were assessed using Cognivue: There were 24 subjects in the mTBI group and 18 subjects in the Normal Control Group. mTBI was diagnosed according to established criteria of the American Congress Of Rehabilitation Medicine (Mild Traumatic Brain Injury Committee) in 1993, which requires the presence of at least one of the following symptoms: initial loss of consciousness <30 min; PTA lasting <24 h; a GCS score of 13–14 at time of injury; a GCS of 13–15 after 30 min; altered mental state at the time of the accident (e.g., confusion, disorientation, etc.); or a focal neurological deficit that may or may not be transient. These patients were referred for a neuropsychological evaluation by their neurologist or primary care physician.

Measures

Each subject was introduced to the Cognivue device and the testing procedure was described to the subject. The Cognivue device is pictured in Figure 1.

Figure 1

Each subject responds to 10 cognitive measures administered by the computer. Each measure provides written directions and allows a few practice trials. Of the 10 measures, 4 measure perceptual processing (visual discrimination) and 4 measure memory. The other 2 measures were composite measures of motor control and visual salience. An overall average score was also computed. A total of 11 dependent variables were captured for analysis.

Figure 3 depicts a sample screen for each subtest.

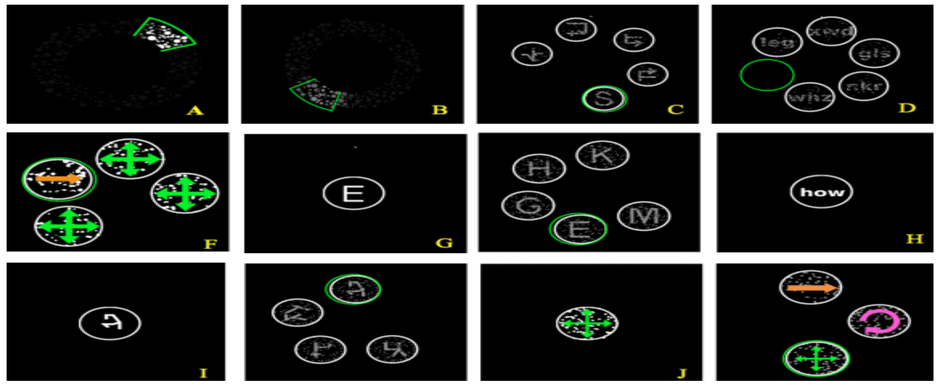


Figure 2 depicts the Cognivue Testing Algorithm and Figure 3 depicts sample screens for each subtest.

Data Analysis

Analysis of variance (ANOVA) comparing means on age was not significant. The average age for mTBI subjects was 43 and normals was 45. Analysis of Variance (ANOVA) comparing all of the 8 cognitive variables and the composite scores was significant indicating that mTBI subjects performed significantly lower on all measures (perceptual tests and memory tests).

Results

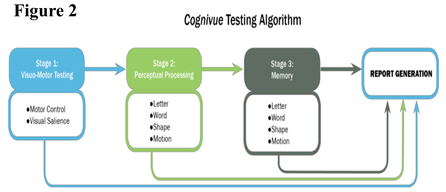
Data analysis revealed that the Cognivue was highly sensitive to the presence of cognitive impairment in people referred for persistent post-concussion syndrome (mTBI), 12-24 months following the concussion. Table 1. summarizes the results of the ANOVA comparing means for each dependent measure by group (mTBI subjects and Normal Controls).

Measure	Normal Means	mTBI Means	p-value
Overall Average	87	58	.000
Adaptive Motor Control	59.5	44	.039
Visual Salience	81	63	.001
Letter Discrimination	75	55	.002
Word Discrimination	86	57	.000
Shape Discrimination	88	62	.003
Motion Discrimination	89	63	.007
Letter Memory	92	59	.000
Word Memory	90	55	.000
Shape Memory	88	58	.000
Motion Memory	91	61	.002

Additional analyses were performed dividing both groups by gender. In the normal control group there were 9 males and 9 females. ANOVA did not demonstrate any gender differences in the Cognivue results. There were 9 males and 15 females in the mTBI group. ANOVA detected a difference between males and females on Visual Salience ($p<.03$). Females performed poorer than males. All other subtests were equivalent between males and females.

On the basis of normative data for people over the age of 55 scores below 50 are considered to represent severe cognitive impairment, scores from 51-74 are considered to represent low-moderate cognitive impairment and scores at or above 75 are considered normal. The above data indicates that mTBI subjects were in the severe failure range on adaptive motor control. All the rest of the measures were in the low-moderate level of impairment as would be expected in this group.

Figure 2



Summary

This investigation compared the mean scores on 10 subtests and a composite average score of the Cognivue device of a group of people with mild TBI and a healthy normal control group. This is the first FDA approved computer-based test of neurocognitive functioning designed to be sensitive to subtle cognitive changes. The results of the analysis indicates that mTBI patients performed significantly lower on all subtests. These findings are consistent with the patient's complaints of persistent cognitive difficulty following the occurrence of concussion greater than 12 months later. The subtests measure perceptual discrimination and memory. Recent advances in this technology suggest that these same subtests are also measuring additional domains: executive function/attention, naming/language, and abstraction.

It is important to understand that Cognivue is a sensitive cognitive screening assessment but it is not a substitute for a comprehensive neuropsychological assessment. Cognivue adds quantitative and also qualitative information to the neuropsychological evaluation and is particularly valuable when the results of neuropsychological assessment are vague or ambiguous. The level of impairment in the mTBI group is mild to moderate with only one measure demonstrating severe impairment.

These results if validated with further research suggest that Cognivue is a viable cognitive screening device that can be used as part of an initial diagnostic interview in addiction treatment programs, primary care offices, chronic pain programs and other specialty medical practices as a method of identifying patients with cognitive impairment. The presence of cognitive impairment impacts medical compliance, specific treatment approaches and general quality of life.

A weakness of the Cognivue system is it relies completely on the visual system therefore visually impaired patients cannot be evaluated with Cognivue.

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