

Title: Correlation between ImPACT reaction time and CRTT efficiency score in concussed athletes

Abstract

The management of sports related concussion is dependent upon a standardized assessment. Reaction time is the most sensitive measure of a concussion when using the ImPACT battery, which was standardized on concussed athletes. However, an athlete's auditory comprehension is rarely assessed systematically. Auditory comprehension status is important in properly managing concussed athletes. The Computerized Revised Token Test (CRTT) measures efficiency time. The purpose of this investigation was to determine the correlation between the ImPACT reaction time and the CRTT-Subtest VIII efficiency score in 51 concussed athletes. These two measures are statistically significantly correlated. Clinical implications are discussed.

Introduction

A concussion is a brain injury induced by traumatic biomechanical forces (McCrary, Meeuwisse, Johnston, Dvorak, Aubry, et al., 2009). Presently, to properly care for an athlete following a concussion, it is imperative that baseline testing is conducted before the start of pre-season practice and the scheduled games. Within two or three days post-concussion an athlete should be re-tested to determine the nature and extent of disruption to his or her ability to learn and process new information efficiently. Without baseline information, the diagnosis, prognosis and treatment of an injured athlete is much more subjective.

At the UTEP Concussion Management Clinic, several evaluation instruments are used. The primary tool is the Immediate Post Concussion Assessment and Cognitive Testing, v. 2.0 (ImPACT; Iverson, Lovell & Collins, 2003a). To assess a patient's ability to follow spoken directions we presently use the Computerized Revised Token Test (CRTT; McNeil, Pratt, Sung, Szuminsky, Ventura et al., 2008), which is a standard clinical assessment instrument. The assessment of auditory comprehension permits us to make a clinical judgment regarding the athlete's ability to follow lecture material and participate in classroom activities. The Paced Auditory Serial Addition Test (PASAT) has been used in the past to assess auditory attentional

processing in concussed individuals (Tombaugh, 2006). However, we chose to use the CRTT because it not only measures processing time but lexical and grammatical performance as well which permits more confidence in making management recommendations. While the ImPACT test addresses the issue of memory for visual material and learning new visual relationships, it does not specifically address auditory comprehension abilities. However, ImPACT reaction time is the most sensitive measure when testing concussed athletes. Since CRTT records response time as well as calculating a response efficiency score we used this measure to determine whether the CRTT efficiency score is a sensitive measure when used with concussed athletes. The CRTT test results will be analyzed and compared with the athlete's reaction time on the ImPACT battery to determine the correlation and application in making clinical management decisions about the return-to-play/classroom.

Methods

Participants: A total of 51 mTBI/concussion patients' performances on the ImPACT test and the CRTT were analyzed. Inclusion criteria for analysis were: no history of attention deficit disorder or learning disorder; not enrolled in any special education services; and no history of brain surgery, meningitis, seizure/epilepsy, or substance abuse. There were 42 males and 9 females that comprised the group. All 51 participants were athletes and distributed across the following sports: football, basketball, volleyball, soccer, ice-hockey, softball, baseball, track & field, and snowboarding. Participants had a mean of 11.26 years of education ($SD = 2.57$), with a range of 5-15 years of education. The mean age of participants was 18.08 ($SD = 4.03$) and a range of 11-38 years of age. Among the participants, 5 were at the semi-professional level, 24 were at the collegiate level, 19 in high school, and 3 in middle school. The participants had the following history of previous concussion: 27 participants reported no history of concussion prior to the current injury, 15 reported a history of one concussion, 6 reported a history of two concussions, 2 participants had a history of three concussions, and 1 participant had a history of five concussions. Time post onset for the first concussion assessment ranged from 1-69 days with a mean days of 6.73 ($SD = 10.23$).

Procedure: Each participant was administered the Subtest VIII of the CRTT and the ImPACT test via computer as part of the post-concussion assessment. The computer software records accurate and inaccurate responses, as well as response time and the speed of the movements of the athlete as they drag and drop the token. At the end of the subtest, CRTT provides an efficiency score (ES), which is an additional measurement of response time and is calculated for individual items, commands, and subtests, as well as overall for the test (Eberwein, Pratt, McNeil, Szuminsky, Doyle 2007).

The ImPACT battery (Iverson, Lovell & Collins, 2003a) was also administered via computer. ImPACT consists of six individual test modules that measure attention, memory, reaction time, and visual processing speed. The *ImPACT Reaction Time Composite Score* used in this study represents the average response time (in milliseconds) on the distracter task of the X's and O's test (Module 3), Symbol Match test (Module 4), and the Color Match test (Module 5) (Iverson, Lovell, Collins, 2003b).

Statistical Analysis

Data analysis was carried out using SPSS version 17. Results from a series of independent Mann-Whitney *U* tests indicated no significant differences in test scores between 1) male and female athletes, 2) athletes with and without self-reported history of concussion, and 3) days post onset (i.e., 12 days or more vs. less than 12 days post-injury). All 51 participants were included in the Pearson correlational analysis.

Results

Means and standard deviations of reaction time and auditory comprehension efficiency scores from the entire sample are included in Table 1. A significant negative correlation was found between athletes' reaction time and their efficiency score on the CRTT (Pearson $r = -.668$, $**p < 0.01$, two-tailed, $r^2 = .446$).

Table 1

Test scores for first post-concussion assessment (PC1): total sample (N = 51)

| | <u>mean</u> | <u>SD</u> | <u>Pearson correlation</u> (r), p |
|-------------------------------|-------------|-----------|--------------------------------------|
| ImPACT reaction time | .69 | 0.26 | r = -.668 |
| composite score | | | p < .01 |
| CRTT average efficiency score | 12.33 | 1.11 | |

Discussion

These results provide valuable clinical information. To date recommendations about the return to play and return to classroom are made primarily based upon the findings of standardized tests like the ImPACT which are primarily visual tasks. The addition of the CRTT to our clinical assessment permits us to make recommendations about the athletes' auditory comprehension based upon objective assessment of their auditory performance. While the correlation of the reaction time measures across the two instruments does not permit the substitution of one for the other, the results suggest that the test instruments are sensitive to the cognitive-linguistic impairment resulting from a concussion. The impairment of auditory comprehension as shown in these results will potentially impact the athletes' performance in academic, social and work situations. Management of the concussion requires that the athlete and their instructors/coaches be made aware of the presence of not only cognitive-linguistic processing difficulties in general but specifically the presence of difficulty in understanding simple spoken messages.

References

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