

# The effect of effort on baseline neuropsychological test scores in high school football athletes

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## Abstract

**OBJECTIVE:** Poor effort on baseline neuropsychological tests is expected to influence interpretation of post-concussion assessment scores. Our study examined effort in an athletic population to determine if poor effort effects neuropsychological test performance. **METHODS:** High school athletes ( $N=199$ ) were administered a brief neuropsychological test battery, which included the Dot Counting Test (DCT) and the Rey 15-Item Test with recognition trial. One-way analyses of variance were used to compare groups with adequate and poor effort test performance.

**RESULTS:** Most athletes ( $N=177$ ; 89%) exerted adequate effort while a number of athletes ( $N=22$ ; 11%) exerted poor effort on the DCT. Statistically significant differences existed between effort groups ( $p < 0.05$ ) on several of the neuropsychological tests.

**CONCLUSIONS:** Poor effort was observed in the athletic population during baseline testing and athletes with poor effort displayed statistically significant differences in performance on neuropsychological tests. Adding an effort test to baseline examinations may improve post-concussion test score interpretations.

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## 1. Introduction

Neuropsychological testing has gained favor as a diagnostic and management tool when evaluating concussed athletes (Aubry et al., 2001; Guskiewicz et al., 2004; McCrory et al., 2005). Several current concussion management guidelines recommend obtaining a baseline neuropsychological assessment in order to obtain a pre-injury estimate of neurocognitive domains most likely affected by concussion (Aubry et al., 2001; Guskiewicz et al., 2004).

The most common approach to concussion-related assessment has been to use a brief neurocognitive test battery, which typically measures memory, cognitive processing speed, working memory, and/or executive function prior to and following a concussive injury (Lovell, Iverson, Collins, McKeag, & Maroon, 1999; Macciocchi, Barth, Alves, Rimel, & Jane, 1996). Obtaining a baseline assessment is critical to interpret post-injury test performance. Conse-

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quently, a repeated measures approach has been advocated by many clinicians and researchers (Guskiewicz, Ross, & Marshall, 2001; McCrea et al., 2003). Typically, athletes who participate in contact sports such as football, ice hockey, wrestling, and soccer are at risk and undergo baseline testing. Unfortunately, if baseline scores are questionably valid secondary to poor effort, clinicians will be unable to accurately interpret changes in test performance following a concussion.

Many factors may influence test performance including, among others, distractions during testing, failure to understand directions, and fatigue, all of which can affect test validity. However, health care practitioners are typically uncertain whether examinees exert maximum effort during baseline concussion assessment. In the absence of formal effort testing, assessments of effort are restricted to subjective clinical impressions. However, research has shown these subjective claims to be prone to error (Faust, Hart, Guilmette, & Arkes, 1998; Green & Iverson, 2001; Green, Rohling, Lees-Haley, & Allen, 2001; Iverson & Binder, 2000). As a result, neuropsychologists have begun to routinely use effort tests when compensation and malingering may be a factor affecting test validity (Green et al., 2001; Iverson & Binder, 2000).

Standardized effort assessments provide methods for identifying invalid test results. Poor effort has been shown to be associated with impaired test performance usually below the usual range for persons who complain of symptoms or disorders on an organic basis (Lezak, Howieson, & Loring, 2004). Additionally, poor test-taking effort may show up as an absence of practice effects for participants who have demonstrated some learning ability in follow-up testing. Furthermore, unaccountable variations or extreme high and low intra-test response patterns are difficult to interpret clinically when effort is poor at baseline testing (Green et al., 2001).

Numerous measures are available to identify poor effort. These measures are designed to give the illusion of test difficulty when the level of difficulty is actually quite minimal. Participants who demonstrate poor effort produce neuropsychological test scores well below peers who score normally on effort tests. Additionally, participants who exhibit sub-optimal performance on formal effort tests typically show invalid neuropsychological test scores (Constantinou, Bauer, Ashendorf, Fisher, & McCaffrey, 2005; Green et al., 2001). While most effort tests such as the Word Memory Test (Green, Iverson, & Allen, 1999) and the Victoria Symptom Validity Test (Slick, Hopp, Strauss, & Spellacy, 1996) are somewhat time intensive, the Rey 15-Item Test (Boone, Salazar, Lu, Warner-Chacon, & Razani, 2002) and the Dot Counting Test (DCT) (Boone, Lu et al., 2002; Frederick, 2002) are two popular brief measures of effort, which would not be expected to place significant time constraints on professionals engaged in concussion management.

To our knowledge, investigators examining sports-related concussion diagnostic and management strategies have not determined the effect of effort on baseline neuropsychological test performance. Consequently, the purpose of this study was to examine if poor effort was present during baseline testing in high school athletes. Additionally, we were interested in whether effort was positively related to neuropsychological test performance in high school athletes during baseline concussion testing. We hypothesized that poor effort would be present to some degree in high school athletes. Further, we hypothesized that those participants with poor effort would perform worse than those participants with adequate effort on baseline neuropsychological test scores.

## 1.1. Procedures

### 1.1.1. Participants

A sample of high school football players ( $N=206$ ;  $15.54 \pm 1.17$  years of age) from five Northeast Georgia high schools was tested prior to the 2005 competitive football season. Any participant who had sustained a musculoskeletal injury or head injury up to 3 months prior to testing was excluded from participation. All participants and guardians read and signed university-approved informed consent and assent forms prior to participating in the study. Athletes were not informed of the hypotheses of the study and were only instructed to perform at optimal levels on the examination.

### 1.2. Data collection procedures

All participants completed a preseason, baseline evaluation utilizing a neuropsychological battery and self-report symptom assessment measures. A health questionnaire was also administered at baseline to obtain demographic information, concussion history, preexisting neurological conditions, and evidence of other medical conditions. Individuals trained by a neuropsychologist in test administration conducted assessments in an appropriate environment.

Table 1  
Neuropsychological test domains, descriptions, scoring and administration time

Measure	Domain	Description	Score range	Administration time (min)
Symptom checklist	Symptomology	Self-rated duration and severity of 22 symptoms	Total score range 0–264. Higher score indicates more severe symptoms	2–3
Standardized assessment of concussion (SAC)	Cognitive function	Brief assessment of neurological status	Total score range 0–30. Lower score indicates more severe impairment	5
Neuropsychological test battery	Cognitive function	Hopkins Verbal Learning Test, Finger Tapping Test, Trails A, Trails B, Symbol Digit Modalities Test, Digit Span	Total score ranged for each individual measure; lower score indicates more severe impairment except for trails (time to completion)	20
Rey-15 item	Effort	Recall and recognize symbols and patterns	Rey combination score: maximum 27	5
Dot Counting Test (DCT)	Effort	Count grouped and ungrouped dots	Average time to completion plus errors	5

### 1.3. Main outcome measures

#### 1.3.1. Neuropsychological battery

Tests utilized included measures that have been extensively studied in sports-related concussion and neuropsychological literature (Field, Collins, Lovell, & Maroon, 2003; Green et al., 2001; Guskiewicz et al., 2001; McCrea et al., 2003) (Table 1). These instruments included the Self-Report Symptom Checklist (symptoms), Standardized Assessment of Concussion (SAC), Rey 15-Item Test with Recognition Trial (R15-R), Hopkins Verbal Learning Test (HVLTL), Finger Tapping Test, Trails A, Trails B, Symbol Digit Modalities Test (SDMT), Digit Span (DS), and the Dot Counting Test. Participants were administered the test battery in the same order to decrease test interference.

#### 1.4. Effort tests

The Rey 15-Item Test with Recognition Trial is an instrument used to identify poor effort. The test consists of 15 symbols on a piece of paper in five rows of three categorically related symbols, each that are well learned and easily identified letters, numbers, or figures. Patients are exposed to the symbols for 10 s, then the characters are withdrawn for 15 s and the patient recalls the symbols. This is immediately followed by a recognition trial with the 15 items plus 15 foils. Scores used in this analysis were the combination score derived by recall correct plus (recognition correct–false positives). Scores of 20 or less were considered to have poor effort (Boone, Salazar et al., 2002). Specificity of a cut score of less than 20 ranged from 61.1% to 100% while sensitivity of the measure ranged from 61.2% to 77.6%. Administration took less than 5 min.

The DCT is a brief task that assesses lack of effort either intentional (malingering) or unintentional (unconscious) by examining an over-learned skill and by measuring time to completion as items become more difficult. The test consists of six serially numbered 3 × 5 cards with randomly arranged dots and six 3 × 5 cards with grouped dots. The cards are shown to the participant one at a time. The participant is told to count and tell the number of dots as quickly as possible. The average time for the ungrouped dots, average time for the grouped dots, and the total number of errors are recorded. A cut score of 14 had a sensitivity of 92% and specificity >90% (Boone, Lu et al., 2002). The time to completion was less than 10 min.

#### 1.5. Statistical analysis

Neuropsychological test data that deviated two standard deviations from the sample mean (plus or minus) on multiple test scores were considered outliers and the data of these participants were removed from the analysis. Seven participants were eliminated from the analysis and statistics were calculated on the remaining 199 participants. All

statistical techniques were computed using SPSS 13.0 (SPSS, Inc., Chicago, IL). To examine differences between groups, a one-way ANOVA was calculated utilizing for each of the outcome measures.

## 2. Results

Collins et al. (1999) have found differences in test performance at baseline for athletes with a previous history of concussion and/or learning disabilities. Accordingly, participants with a history of learning disability ( $N=25$ ) and concussion history ( $N=50$ ) were analyzed separately. Thirty-six percent of the learning-disabled group ( $N=4$ ) demonstrated poor effort, while 17.6% of the participants with previous history of concussion ( $N=5$ ) demonstrated poor effort (Fig. 1). A one-way ANOVA revealed no significant differences in test performance between those with poor effort in the learning-disabled, previous history of concussion, and adequate effort group (Table 2). Consequently, the learning-disabled and previous history of concussion group were included into the full analysis between those with poor and adequate effort.

The adequate and poor effort groups did not differ statistically in terms of age ( $F(1, 198)=0.446, p=0.50$ ), grade ( $F(1, 198)=0.07, p=0.78$ ), school ( $\chi^2(5, N=199)=3.97, p=0.68$ ), or ethnicity ( $\chi^2(3, N=199)=3.85, p=0.27$ ). DCT performance was poor in 22 athletes (11%) while 2% ( $N=4$ ) of athletes demonstrated poor effort on the Rey 15-Item Test with recognition trial. For each test, the athletes were divided into two groups (adequate effort and poor effort) based upon suggested cut scores (Boone, Salazar et al., 2002). For the DCT, 177 athletes (89%) were determined to have adequate effort. On the R15-R (98%) athletes exerted adequate effort while four (2%) athletes were found to have poor effort. Athletes who exerted poor effort on the R15-R also exerted poor effort on the DCT. Due to the limited number of athletes with poor effort on the R15-R, traditional assumptions in statistical analysis were violated. Therefore, only descriptive analyses of test means were completed (Table 3). Examining group means displayed a general trend for the poor effort group to perform worse than the adequate effort group.

Percentage of Suspect Effort By Classification

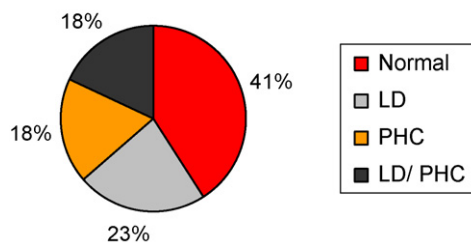


Fig. 1. Percentage of poor effort by clinical classification. LD, self-reported learning disability; PHC, self-reported previous history of concussion; LD/PHC, athletes with both self-reported learning disability and previous history of concussion.

Table 2  
Descriptive data for effort groups using Dot Counting

Tests	Adequate effort ( $N=177$ )	Suspect effort ( $N=22$ )	Suspect effort (no PHC/LD) ( $N=9$ )	Suspect effort (PHC) ( $N=5$ )	Suspect effort learning disability (LD) ( $N=4$ )	Suspect effort PHC and LD ( $N=4$ )
Trails A	34.59 (12.81)	39.79 (11.44)	33.71 (6.59)	46.72 (12.67)	42.88 (14.03)	48.71 (20.41)
Trails B	68.92 (22.00)	87.85 (24.07)	86.22 (17.75)	83.12 (14.85)	81.81 (9.10)	83.94 (1.17)
SDMT	52.78 (9.45)	45.86 (11.23)	46.66 (8.23)	46.33 (11.59)	45.37 (14.58)	44.67 (13.05)
DS total	14.90 (3.44)	12.18 (3.28)	12.66 (3.64)	11.33 (3.39)	12.75 (3.32)	11.67 (5.03)
Dominant Tap Test	56.84 (7.28)	52.79 (8.26)	55.64 (6.10)	52.44 (5.49)	50.30 (9.51)	48.93 (2.61)
HVLT	23.98 (4.25)	21.31 (5.41)	23.88 (4.25)	20.11 (4.83)	19.00 (5.07)	19.00 (3.60)
SAC	26.43 (1.93)	24.54 (2.38)	25.44 (1.33)	23.88 (3.14)	24.37 (2.55)	24.00 (3.46)
Symptoms	2.17 (3.07)	3.59 (3.36)	2.44 (3.16)	3.67 (2.96)	5.87 (2.64)	6.00 (1.00)

SDMT, Symbol Digit Modalities Test; DS total, total digit span score; HVLT, Hopkins Verbal Learning Test; SAC, standardized assessment of concussion.

Table 3  
Descriptive data for effort groups using R15-R

Test	Adequate effort mean (S.D.)	Poor effort mean (S.D.)
Self-report symptoms	2.21 (2.89)	3.00 (3.56)
SAC total	26.24 (2.09)	25.25 (0.50)
HVLT total	23.76 (4.31)	20.25 (6.18)
Dominant Tapping Test	56.89 (8.22)	58.50 (3.89)
Trails A	34.60 (11.03)	40.09 (9.65)
Trails B	69.58 (19.52)	90.79 (34.67)
SDMT	52.26 (9.63)	42.50 (13.08)
DS total	14.63 (3.54)	13.75 (2.21)

SDMT, Symbol Digit Modalities Test; DS total, total digit span score; HVLT, Hopkins Verbal Learning Test; SAC, standardized assessment of concussion.

For the DCT, significant differences in neuropsychological test performance were observed between groups who performed well and poorly. Statistically significant differences were noted for Trails B ( $F(1, 196) = 14.31, p < 0.01$ ); SDMT ( $F(1, 196) = 10.112, p < 0.01$ ); DS<sub>tot</sub> ( $F(1, 196) = 12.48, p < 0.01$ ); DS back ( $F(1, 196) = 14.45, p < 0.01$ ); HVLT ( $F(1, 196) = 6.96, p = 0.02$ ); SAC ( $F(1, 196) = 17.918, p < 0.01$ ); and the Dominant Hand Tap test ( $F(1, 196) = 5.319, p = 0.02$ ). On all these neuropsychological tests, the poor effort group performed more poorly than the adequate effort group.

### 3. Discussion

A small percentage of athletes studied demonstrated poor effort on the DCT and the R15-R during baseline testing. The presumption that all high school athletes exert adequate effort during all assessments was proved to be incorrect. Our study utilized brief measures that only identified grossly poor effort, and we still identified that 1 out of the 10 athletes had poor effort during baseline testing. Additionally, statistically significant differences existed between athletes with poor and adequate effort on neuropsychological test scores. Our participants with poor effort performed below the adequate effort group on tests measuring information processing, memory, attention/concentration, learning, and gross motor speed.

There also was a trend for those with learning disabilities and a previous history of concussion to perform more poorly on the neuropsychological tests compared to peers without a history of neurocognitive injury disorders. In addition, athletes with a history of LD and concussion were more likely to evidence impaired performance on effort tests when compared to peers with no history of LD or concussion. Therefore, until this finding can be examined in a larger sample, athletes with a history of LD and/or concussion should be closely monitored during baseline testing.

Determining whether athletes exert adequate effort is especially difficult when clinicians are not expecting participants to perform poorly (Faust et al., 1998). Assuming that adequate effort is being expended when testing at baseline may result in unwanted lowering of baseline scores. This would ultimately lead to inaccurate interpretation of neuropsychological test score comparisons following a concussion. Consequently, adding effort tests to baseline assessments of all athletes would be expected to help correctly identify poor effort and increase the validity of interpretations regarding baseline neuropsychological test scores. Unfortunately, while effort assessment is common in clinical neuropsychological practice, effort testing has not been included in concussion assessment for athletic populations.

Our study has several limitations, which merit comment. First, the number of participants who displayed poor effort was not equally distributed between the two effort tests. Although administered at different times in the test battery, athletes determined to exert poor effort utilizing the R15-R also had poor effort on the DCT. The Rey 15-Item Test with recognition trial has not been shown to be as sensitive to poor effort as longer more subtle effort tests. Therefore, the increase of participants with poor effort may be a result of a higher sensitivity with the DCT. Since the R15-R did not identify any athletes missed by the DCT, use of the R15-R does not appear warranted.

Secondly, administration times within the battery may have affected outcome. Potentially, a participant's effort level may change within the battery administration time. Therefore, by the end of the battery (when the DCT was administered) effort levels may have decreased. Effort tests are used in extended clinical examinations without any evidence of fatigue, causing a decline in performance. However, future research that involves counterbalancing the

test order may eliminate the theory that fatigue plays a role in effort test performance in short concussion assessment batteries. In any case, use of effort tests when performing sport concussion assessments seems important and can be administered early in the examination.

Thirdly, the normative values for both effort tests were developed on clinical and control populations older than 16 years of age. There was an inherent assumption that the adolescent participants would perform equally compared to their adult counterparts. After a comprehensive literature search, there appears to be very few effort tests consistently (Tests of Memory Malingering, Word Memory Test) used within research for adolescent populations. However, the available tests for adolescent populations are lengthy and would not be adequate in a brief neuropsychological battery administered at baseline. Caution should be used during interpretation of effort scores when utilizing cut scores that are not specifically designed for use in adolescent populations. Further investigations utilizing a larger sample of adolescents will provide a sample that might be used for normative purposes.

The measures in this research were used due to common use in previous effort assessment research and because they could easily be administered within the protocol battery in a short period of time. The determination of poor effort utilizing these brief measures of effort most likely produce a conservative estimate of the athletes who evidenced poor effort. More sensitive tests with higher specificity would most likely detect additional athletes with poor effort and likely allow for more valid interpretation of post-concussion test score comparisons.

Research involving neuropsychological testing without a psychometric measure of effort might produce invalid interpretations regarding comparisons to baseline scores. If 11% of the sample has poor effort, then 11% of the sample has invalid neuropsychological test scores. Direct comparison to an athlete's baseline with poor effort might indicate an improvement following post-concussion injuries when no change is present. Obtaining a measure of effort would allow the removal of acceptance of invalid baseline tests to increase the accuracy of scores within concussion assessment.

This research provides evidence that utilization of an effort test during concussion assessment is vital in validating baseline assessments. Clinicians should incorporate effort tests within their concussion assessment battery to provide additional validity evidence, especially for baseline and post-injury comparisons. Although numerous effort measures are available, brief, less sensitive measures of effort could be used as a screening tool. If an athlete exerts poor effort using these brief measures of effort, utilization of a more comprehensive effort battery is suggested. If poor effort is suspected during testing, the clinician should reiterate that the participant try their best during all portions of the test battery. Further, if poor effort is evident after baseline neuropsychological testing we recommend administering the test battery again when a psychometric effort test reveals adequate effort to validate baseline scores. The participant should be informed that the test results were poor because of effort, which resulted in lower test scores than expected; therefore, they are repeating the test. Additional studies need to replicate the presence of poor effort in different athletic populations. Increasing the sample size to include clinical samples, regional and/or national statistics will strengthen the findings of this study.

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