Exploring Differences in Computerized Neurocognitive Concussion Testing Between African American and White Athletes

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Abstract

The purpose of the current study was to explore potential differences in pre- and post-concussion performance on a computerized neurocognitive concussion test between African American and White high-school and collegiate student-athletes. A prospective case–control design was used to compare baseline and 2- and 7-day post-concussion computerized neurocognitive performance and symptoms between 48 White and 48 African American athletes matched for age, gender, and concussion history. The Immediate Post-Concussion Assessment Cognitive Test (ImPACT) version 2.0 (NeuroHealth System, LLC, Pittsburgh, PA, USA) computer software program was used to assess neurocognitive function (i.e., verbal and visual memory, motor processing speed, and reaction time) and concussion symptoms. Regardless of race/ethnicity, there were significant decrements in computerized neurocognitive performance and increased symptoms following a concussion for the entire sample. African Americans and Whites did not differ significantly on baseline or post-concussion verbal memory, visual memory, reaction time, and total reported symptoms. However, African American participants were 2.4 × more likely to have at least one clinically significant cognitive decline on ImPACT at 7 days post-concussion and scored lower at 7 days post-concussion compared with baseline on processing speed than White participants. The authors concluded that the baseline ImPACT test was culturally equivalent and construct valid for use with these two racial/ethnic groups. However, in contrast, the findings support deleterious performance for the African American athletes compared with the White athletes on the ImPACT post-concussion evaluation that is of critical clinical relevance and warrants further research.

Keywords: Head injury; Traumatic brain injury; Cross-cultural/minority; Assessment

Introduction

Researchers estimate that each year approximately 3.8 million concussions occur in sport in the United States (Langlois, Rutland-Brown, & Wald, 2006). Traditionally, sports concussion was assessed and managed using grading scales that were predicated largely on the presence of loss of consciousness (LOC: Lovell, Collins, Fu, Burke, & Podell, 2001). By the 1990s, paper and pencil neurocognitive tests gained popularity in the management of sports concussion (e.g., Barth et al., 1989; Collins et al., 1999). More recently, researchers have advocated the use of computerized neurocognitive testing as one tool in a comprehensive and individualized approach to managing this injury (McCrory et al., 2005). Computerized neurocognitive testing has been shown to be effective in identifying the subtle changes in cognitive performance following concussion (Collie, Darby, & Maruff, 2001; Collie et al., 2003; Iverson, Brooks, Collins, & Lovell, 2006; Iverson, Lovell, & Collins, 2005; Lovell & Collins, 2002; Lovell et al., 2001; Reeves, Winter, Bleiberg, & Kane, 2007). Moreover, this technology allows for more individualized and empirically based injury management than traditional grading scales (Cantu, 2006; Van Kampen, Lovell, Pardini, Collins, & Fu, 2006). This innovative method of assessing cognitive performance offers increased...
consistency in administration and scoring, the ability to create alternate versions, and the ability to measure many different types of responses at one time (Kane & Kay, 1992). Furthermore, computerized neurocognitive testing is a cost-effective alternative to the former paper-and-pencil testing batteries (Goldstein, 1990). In summary, computerized neurocognitive concussion testing has been a valuable addition to sports medicine professionals by providing them with reliable information on the cognitive status of concussed athletes (Van Kampen et al., 2006).

Several factors including age (Buzzini & Guskiewicz, 2006), gender (Covassin et al., 2006), learning disability (Collins et al., 1999), and concussion history (Iverson, Gaetz, Lovell, & Collins, 2004) have been reported by researchers to influence neurocognitive outcomes following concussion. However, researchers have advocated for the investigation of additional factors that might influence neurocognitive testing outcomes (Field, Collins, Lovell, & Maroon, 2003). One such factor that has yet to be studied with regard to neurocognitive concussion outcomes is race/ethnicity.

Race/Ethnicity and Neurocognitive Performance

Previously, researchers have argued against the use of race/ethnicity as a research construct due to its potential for reinforcing racial stereotypes (e.g., Bagley, 1995; Fullilove, 1998). Although we acknowledge the pitfalls (i.e., reinforcing prevailing stereotypes) of over-generalizing and simplifying research involving race/ethnicity as a construct, we echo William’s (1997) suggestion that racial/ethnic differences are indeed important to consider in the use and interpretation of neurocognitive testing. Researchers have suggested that educational, linguistic, and cultural factors may influence performance on neurocognitive tests (Heaton, Ryan, Grant, & Matthews, 1996; Manly et al., 1998).

Early studies on race/ethnicity and neurocognitive testing reported differences between Whites and African Americans on the 11 Wechsler Adult Intelligence Scale-Revised (WAIS-R; Kaufman, McLean, & Reynolds, 1988) and the Wechsler Intelligence Scale for Children-Revised (Jensen & Reynolds, 1982). Specifically, Kaufman and colleagues (1988) reported that Whites scored more than 1 SD higher than African Americans on the Block Design WAIS-R subtest. In addition, a similar difference of approximately 1 SD was found for Vocabulary, Arithmetic, Comprehension, and Information. The least discriminating tasks were Digit Span, Picture Arrangement, and Digit Symbol that yielded a racial difference of approximately 1.5 SD (Kaufman et al., 1988). These researchers speculated that the observed differences in neurocognitive performance might be due to inherent cultural bias in the construction of the test items.

Subsequent research by Mayfield and Reynolds (1997) examined neurocognitive performance differences between African American and White participants aged 5–19 years using the Test of Memory and Learning (TOMAL: Reynolds & Bigler, 1994). Mayfield and Reynolds reported only one significant difference for race/ethnicity on the 14 TOMAL measures of memory. Specifically, and in contrast to the findings of other studies, they reported that African Americans scored higher than Whites on the Letters Forward component of the TOMAL. The authors concluded that at least on memory tests, there were no remarkable differences between healthy African Americans and Whites. They argued further that their findings suggest that race/ethnicity may play no significant role in neurocognitive tests in general and that clinicians should instead focus on individual test differences regardless of race/ethnicity.

More recently, and in contrast to the findings of Mayfield and Reynolds (1997), researchers reported differences between Whites and African Americans on neurocognitive test performance (e.g., Sandifer, Frank, Montgomery, Nichols, & Cooper, 2005). The results of Sandifer and colleagues (2005) are similar to those reported by Kaufman and colleagues (1988) and Jensen and Reynolds (1982). Specifically, Sandifer and colleagues examined race, age, and gender differences in performance scores on the Arizona Battery for Communication Disorders of Dementia (ABCD) in a sample of White and African American men and women aged 15–25 years. Although they reported no differences for gender or age Sandifer and colleagues did report that White participants scored higher than African Americans on Total Overall and the Linguistic Expression components of the ABCD.

On the surface, the limited empirical data reviewed above appear to provide tentative support for differences in performance between Whites and African Americans on neurocognitive tests. These reported differences have led some researchers (e.g., Manly, 2005) to reexamine the role of separate neurocognitive norms for African American and other racial/ethnic groups. The use of separate norms is based on differences in test performance that are presumed to be culturally driven. However, as Manly (2005) suggested, it is important to note that separate neurocognitive normative data for African American individuals still revolve around the measures themselves, which were developed by and for well-educated White individuals. This inherent cultural bias cannot be overcome simply through the use of separate norms, which may have the unintended effect of reinforcing racial/ethnic stereotypes of neurocognitive performance. Therefore, the use of separate neurocognitive norms for African American individuals is wrought with pitfalls. The notion that racial/ethnic identity is equitable across individuals in particular is problematic, as there is tremendous within-group variability in factors that
might influence neurocognitive performance such as educational background and socioeconomic status (SES). Consequently, these other variables must be considered by researchers examining differences in neurocognitive performance between African American and White individuals.

Variables Influencing Racial/Ethnic Differences in Neurocognitive Performance

Among the factors that have been proposed by researchers to influence neurocognitive performance differences among racial/ethnic groups are education and reading level (as opposed to the level of school; e.g., Teng & Manly, 2005). Reading level in particular seems to vary considerably within and between racial/ethnic groups and may explain much of the variability in neurocognitive performance attributed to race/ethnicity (Manly, Jacobs, Touradji, Small, & Stern, 2002). SES, or more specifically the quality of education, has been reported by researchers (e.g., Manly et al., 2002) to play a significant confounding role in reported differences in neurocognitive performance among racial/ethnic groups. Preliminary interpretations of recent studies suggest that lower SES is negatively related to neurocognitive achievements (Noble, Norman, & Farah, 2005). In fact, Feinstein (2003) suggested that the cognitive ability of a 10-year-old child is more a result of his SES than his cognitive ability at age 2.

Similarly, educational background affects neurocognitive test performance and may underlie reported cultural differences. Shuttleworth-Edwards and colleagues (2004) conducted a study of WAIS-III performance in South Africa among African and English first language young adults representing three distinct groups: (a) Black African first language with disadvantaged educational backgrounds, (b) Black African first language with advantaged educational backgrounds, and (c) White English first language with advantaged backgrounds. The researchers reported that Black African first language young adults with disadvantaged educational backgrounds scored 20–30 points lower on the WAIS-III compared with United States and South African White English first language standards. However, Black African first language young adults performed similar to U.S. and South African White English first language WAIS-III standards when they were from similarly advantaged educational backgrounds as their White counterparts. These results suggest that educational background plays a significant role in determining neurocognitive performance and must be considered in cross-cultural neurocognitive research. In summary, any differences in computerized neurocognitive performance that might be attributed to race/ethnicity must also acknowledge the effects of other factors such as SES, reading level, and particularly educational background. As such, it is important for researchers to either assess educational level or sample educationally similar groups when examining racial/ethnic differences in computerized neurocognitive performance.

Although there have been no studies examining potential racial/ethnic differences in computerized neurocognitive test performance related to sports concussion, researchers have examined cross-cultural differences (Shuttleworth-Edwards, Whitefield-Alexander, Radloff, Taylor, & Lovell, 2009). Specifically, Shuttleworth-Edwards and colleagues (2009) compared using the Immediate Post-Concussion Assessment Cognitive Testing (ImPACT) the neurocognitive performance and concussion-related symptoms of English speaking, mostly White South African rugby players with a similar comparison group of U.S. football players. The researchers reported that the two groups’ neurocognitive performance was similar, but that the South African group reported higher concussion-related symptoms. They concluded that although the U.S.-derived neurocognitive normative data were appropriate for use with South African athletes, culture-specific differences in symptom reporting and sensitivity should be considered in clinical management of concussion. The researchers also noted that neurocognitive equivalence is less likely across racial/ethnic groups, where educational disparities are more pronounced.

Purpose of the Study

The purpose of the current study was to explore potential differences in baseline and post-concussion performance on a computerized neurocognitive concussion test between African American and White high-school and collegiate student-athletes. There is limited empirical support for differences in neurocognitive performance between African Americans and Whites. In fact, differences previously reported may be obfuscated by factors such as educational background. Hence, we hypothesized that there would be no differences in computerized neurocognitive performance at baseline between African American and White student-athletes who were from similar educational backgrounds. In contrast, and given the exploratory nature of this study and the fact that educational equivalence does not translate to clinical post-injury equivalence, there was insufficient support to warrant a directional hypothesis for post-injury neurocognitive performance between the two groups.
Materials and Methods

Design

A prospective case–control design was used to compare baseline and 2- and 7-day post-concussion neurocognitive performance and symptoms between White and African American athletes. The independent variables were race/ethnicity (White, African American) and time (baseline, 2 days post-concussion, and 7 days post-concussion). The dependent variables were computerized neurocognitive composite scores for verbal memory, visual memory, reaction time, motor processing speed, and total concussion symptoms.

Participants

A total of 96 (48 African American and 48 White) concussed high-school (n = 14) and collegiate (n = 82) student-athletes were selected for inclusion in the study from a multisite concussion surveillance database. The participants ranged in age from 14 to 23 years, with each racial/ethnic group comprising the same age range. All participants in the study reported English as their first language. Geographically, the sample represented institutions located in the southeastern (n = 22), northeastern (n = 40), and mid-western (n = 34) United States. Participants were matched for history of concussion, age, gender, and when possible, sport and institution. Although individual subject’s educational performance was not measured directly, all matched participants were from similar academically performing institutions with comparable standardized test scores, educational resources, and classroom sizes. A summary of average age, height, weight, and concussion history for the White and the African American participants is presented in Table 1. Participants with a recent or current unresolved concussion, traumatic brain injury, diagnosed learning disability, psychiatric disorder, or substance abuse were excluded from the study. The majority of participants represented American football (n = 55), men’s (n = 8) and women’s (n = 7) soccer, men’s wrestling (n = 11), and women’s gymnastics (n = 6). Table 2 provides a breakdown of the representation of each sport by race/ethnicity and gender. There were a total of 78 men and 18 women in the study. Each racial/ethnic group included 39 men and 9 women.

Definition of Concussion

A concussion was defined as an altered mental state that may or may not have included an LOC and was the result of an impact injury (American Academy of Neurology, 1997). The presence of a concussion using the above definition was

| Table 1. Age, height, weight, and concussion history for White (n = 48) and African American participants (n = 48) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | White | | African American | | Total | | | | | | |
| | M | SD | M | SD | M | SD | M | SD | M | SD | M | SD |
| Age (years) | 19.04 | 2.11 | 19.63 | 2.02 | 19.33 | 2.08 | | | | | |
| Height (m) | 1.78 | 0.11 | 1.80 | 0.09 | 1.79 | 0.10 | | | | | |
| Weight (kg) | 85.78 | 26.00 | 88.66 | 21.97 | 87.22 | 24.00 | | | | | |
| Concussion history | 0.81 | 1.09 | 1.00 | 1.29 | 0.91 | 1.19 | | | | | |

| Table 2. Sports representation for male and female White (n = 48) and African American participants (n = 48) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | White | | African American | | Total | | | | | | |
| | Men | Women | Men | Women | Men | Women | Men | Women | Men | Women | Men | Women |
| American Football | 27 | 0 | 28 | 0 | 55 | 0 | | | | | |
| Soccer | 3 | 4 | 5 | 3 | 8 | 7 | | | | | |
| Lacrosse | 0 | 1 | 1 | 1 | 1 | 2 | | | | | |
| Basketball | 0 | 0 | 0 | 2 | 0 | 2 | | | | | |
| Baseball/Softball | 1 | 0 | 1 | 1 | 2 | 1 | | | | | |
| Crew | 1 | 0 | 0 | 0 | 1 | 0 | | | | | |
| Gymnastics | 0 | 4 | 0 | 2 | 0 | 6 | | | | | |
| Wrestling | 7 | 0 | 4 | 0 | 11 | 0 | | | | | |
| Total | 39 | 9 | 39 | 9 | 78 | 18 | | | | | |
determined during the study by certified athletic training professionals (ATCs) and/or team physicians. Initial on field presenta
tion of concussion as assessed by ATCs and physicians was similarly mild (i.e., no LOC, post-traumatic amnesia [PTA], or
disorientation) for all but three participants (two White and one African American), one of which involved a brief (i.e., <10 s)
LOC and two (one White and one African American) involved PTA at the time of injury. However, these participants did not
exhibit more severe or protracted post-concussion neurocognitive decrements or symptoms than the other participants in the
study.

Computerized Neurocognitive Concussion Testing

The ImPACT version 2.0 (NeuroHealth System) computer software program was used to assess neurocognitive function and
reported concussion symptoms in this study. The ImPACT test takes approximately 25–30 min to complete and comprises
three main sections. In the first section, subjects self-report demographic and descriptive information including age; gender;
and self-reported history of alcohol and drug use, learning disabilities, attention deficit hyperactive disorders, major neurological
and psychiatric disorders, migraine headaches, and previous concussions. In the second section, subjects rate on a 7-point
Likert scale the presence of each of 22 common concussion-related symptoms including headache, memory problems, confusion,
and fogginess. The third section of the test consists of six neuropsychological tests that evaluate attention, verbal recogni
tion memory, visual working memory, visual processing speed, reaction time, numerical sequencing ability, and learning.
These six neuropsychological tests yield four neurocognitive composite scores in the areas of verbal and visual memory, reaction
time, and processing speed. The ImPACT test is a valid and reliable measure of neurocognitive performance related to
concussion. Using reliable change indices, repeated administrations over a 2-week period revealed no practice effects
(Iverson, Lovell, Collins, & Norwig, 2002). In another study, Iverson, Lovell, and Collins (2005) reported 1-week test–
retest reliability coefficients for the composite scores as follows: 0.70 for verbal memory, 0.67 for visual memory, 0.79 for
reaction time, and 0.86 for processing speed; within-subject comparisons revealed significant test–retest differences for
only the processing speed composite scores. Schatz, Pardini, Lovell, Collins, and Podell (2006) documented a combined sen
sitivity of 81.9% for ImPACT indices and total symptom score, and a specificity of 89.4%; positive likelihood ratio was
approximately 8:1; and negative likelihood ratio was 2:1.

Protocol

Approval for the study and use of human subjects was provided by each participating university’s Institutional Review
Board. Permission was then obtained from all necessary administrators, team physicians, and ATCs at each participating insti
tution. Prior to their participation all student-athletes provided written informed consent or assent, if they were a minor.
Parental consent was also obtained for all minors included in the study. Prior to the start of the season, all athletes completed
a baseline ImPACT test. At this time, the athletes were asked to self-report their race/ethnicity in addition to other demographic
information. Over the course of the 2-year study period, ATCs and/or team physicians at each institution were responsible for
referring any athlete who incurred a concussion to the researchers for post-concussion ImPACT testing. Each post-concussion
ImPACT test was administered at 2 days and 7 days post-concussion.

Data Analysis

The ImPACT composite scores for verbal memory, visual memory, motor processing speed, reaction time, and reported
symptoms were the dependent variables in all analyses. Higher scores on verbal and visual memory and motor processing
speed indicate better performance. Verbal and visual memory scores are presented as a percentage score out of 100, and
motor processing speed as a numerical composite score. All reaction time scores are presented in seconds with lower
scores indicating faster reaction time (i.e., better performance). Total reported symptoms are also listed at each post-concussion
testing occasion.

A series of repeated-measures 2 (group) × 3 (time) ANOVAs with the Bonferroni corrections were performed on verbal and
visual memory, reaction time, motor processing speed, and total concussion symptoms with race as the between-subjects
factor. Reliable change estimates (RCEs) at the 80% confidence interval (CI) were used to determine if athletes experienced
clinically significant declines in any of the ImPACT neurocognitive composites following a concussion. Odds ratios
(ORs) from a series of \( \chi^2 \) analyses for race/ethnicity and the RCEs were then calculated to determine risk for clinically sig
nificant declines in neurocognitive performance at 2 and 7 days post-concussion. Statistical significance for all tests was set
at \( p < .05 \). All analyses were conducted using SPSS version 15.1.
Results

Repeated-Measures ANOVAs

The results of the repeated-measures ANOVAs with Bonferroni corrections supported within subjects main effects for time on the verbal memory, $F(3, 93) = 11.19, p = .001$; visual memory, $F(3, 93) = 5.59, p = .004$; motor processing speed ImPACT neurocognitive composites, $F(3, 93) = 4.87, p = .009$; reaction-time ImPACT neurocognitive composites, $F(3, 93) = 4.42, p = .013$; and symptoms’ scores, $F(3, 93) = 19.73, p = .001$. As expected, participants performed worse on the verbal and visual memory and motor processing speed and reaction-time ImPACT neurocognitive composites and reported more symptoms at 2 days post-concussion compared with baseline (see Table 3 for means and SDs). Participants performed better on the verbal and visual memory, and motor processing speed ImPACT neurocognitive composites and reported fewer symptoms at 7 days post-concussion compared with 2 days post-concussion. There was no significant difference in reaction time between 7- and 2-day post-concussion. There were no significant differences on any of the ImPACT neurocognitive composite scores or symptoms between baseline and 7 days post-concussion. The results did not support any differences in baseline performance between the two groups. Additional results from the repeated-measures ANOVAs indicated no significant between-subjects main-effect differences on verbal and visual memory and reaction time composite scores or total symptoms from baseline to post-concussion between African American and White participants. However, White participants demonstrated an apparent practice effect on motor processing speed from baseline ($M = 38.87, SD = 7.28$) to 7 days post-concussion ($M = 40.70, SD = 7.82$), whereas African American participants did not (baseline: $M = 36.54, SD = 8.46$). The results of a post hoc $t$-test confirmed that African American and White participants differed significantly on motor processing speed scores at 7 days post-concussion ($t(251) = 2.51, p = .014$) but not at baseline ($t(131) = 1.31, p = .19$). Also of note, the within-subjects interactions between race/ethnicity were not significant ($p = .51$ [processing speed] to $p = .82$ [verbal memory]).

RCEs at 2 and 7 Days Post-Concussion

RCEs at the 80% CI were used to determine if athletes experienced clinically significant declines in the ImPACT modules at 2 and 7 days post-concussion. The results of a subsequent series of $\chi^2$ analyses with ORs supported a non-significant ($\chi^2 = 3.38, p = .07$) trend indicating that at 2 days post-concussion African American participants were 2.4 times more likely to experience at least one clinical change in cognitive performance than White participants (Table 4). Another non-significant trend suggested that at 2 days post-concussion African American participants were 2.2 times more likely ($\chi^2 = 3.50, p = .06$) to demonstrate at least two clinically significant declines in any ImPACT composite score than

| Table 3. Summary of means and standard deviations for ImPACT composite scores and total symptoms ($n = 96$) at baseline, and 2- and 7-daypost-concussion for African American and White participants |
|---------------------------------|--------------------------|--------------------------|
|                                | Baseline                | 2 Days post-concussion    | 7 Days post-concussion |
|                                | $M$  | $SD$    | $M$  | $SD$    | $M$  | $SD$    |
| Verbal Memory                  |     |         |     |         |     |         |
| African Americans              | 0.85 | 0.10    | 0.79** | 0.13    | 0.84** | 0.11    |
| Whites                         | 0.84 | 0.09    | 0.77** | 0.13    | 0.82** | 0.11    |
| Visual Memory                  | 0.86 | 0.10    | 0.81** | 0.12    | 0.85** | 0.11    |
| African Americans              | 0.73 | 0.15    | 0.69** | 0.15    | 0.73** | 0.12    |
| Whites                         | 0.73 | 0.13    | 0.68** | 0.15    | 0.72** | 0.13    |
| Reaction Time                  | 0.73 | 0.16    | 0.69** | 0.14    | 0.75** | 0.12    |
| African Americans              | 0.54 | 0.08    | 0.59** | 0.15    | 0.57   | 0.11    |
| Whites                         | 0.55 | 0.08    | 0.61** | 0.19    | 0.58   | 0.11    |
| Motor Processing Speed         | 0.53 | 0.09    | 0.57** | 0.13    | 0.55   | 0.10    |
| African Americans              | 37.85 | 7.63   | 35.79** | 8.94    | 38.62** | 8.37    |
| Whites                         | 36.87 | 7.90   | 34.02** | 8.90    | 36.54** | 8.46    |
| Total Symptoms                 | 38.87 | 7.28   | 37.57** | 8.71    | 40.70** | 7.82    |
| African Americans              | 8.35 | 13.57   | 18.67** | 19.78   | 10.66** | 13.73   |
| Whites                         | 7.73 | 10.87   | 16.42** | 20.25   | 9.00**  | 13.33   |
|                                | 9.00 | 15.92   | 18.67** | 19.78   | 12.31** | 14.06   |

*Significantly different from baseline score.

Significantly different from 2-day post-score.

*p < .05.
White participants. Finally, the results indicated that at 7 days post-concussion African American participants were 2.4 times \( (\chi^2 = 4.29, p = .03) \) more likely to experience one clinically significant cognitive decline than White participants.

**Discussion**

**Summary of the Results**

The current study explored potential differences in pre- and post-concussion computerized neurocognitive performance and symptoms between African American and White collegiate and high-school student-athletes. Regardless of race/ethnicity, there were significant decrements in computerized neurocognitive performance and increased symptoms following a concussion for the entire sample. The findings indicated that African Americans and Whites did not differ significantly on baseline or post-concussion verbal memory, visual memory, reaction time, and total reported symptoms. However, White participants demonstrated a practice effect on motor processing speed from baseline to 7 days post-injury, whereas African American participants did not. African American participants were also 2.4 \( \times \) more likely to have at least one RCE on ImPACT at 7 days post-concussion than White participants.

**Baseline Neurocognitive Performance**

The results of the study indicated that there were no neurocognitive differences between African American and White participants at baseline. This finding, together with previous research (e.g., Iverson et al., 2002, 2005; Schatz et al., 2006) on the validity of computerized neurocognitive concussion testing, suggests that the ImPACT was a culturally equivalent and effective pre-morbid measure of neurocognitive performance across the two racial-ethnic groups in the current study. Also, in spite of the fact that the current normative data for the ImPACT computerized neurocognitive concussion testing were based on a primarily White sample, the current study’s findings do not support the creation of separate normative values for African Americans, as there were no baseline differences between the groups. As Manly (2005) suggested, the primary purpose of separate normative data for any group is predicated on improving diagnostic accuracy within that group. However, the findings in the current study suggest that the baseline ImPACT neurocognitive concussion test is accurate for use with both African Americans and Whites.

**Post-Concussion Differences in Neurocognitive Performance**

The results of the study suggested that there were subtle differences in risk for post-concussion RCEs and in neurocognitive decrements in processing speed between African American and White participants. The tentative finding in the current study regarding the 2.4 \( \times \) increased risk for one or more RCEs at 7 days post-concussion among African Americans compared with Whites may be attributable to several underlying reasons. For example, the researchers noted anecdotally that some of the concussed high-school African American athletes included in the current study reported limited awareness of concussion and its signs and symptoms. As a result of some athletes’ lack of awareness of concussion symptoms and signs, some concussions and
subsequent neurocognitive testing outcomes and RCEs among the African American athletes in the current study may have represented the compounded effects of multiple unrecognized/unreported concussions.

Because the increased risk among African Americans for one or more RCEs occurred only at the 7 day interval, they may have simply experienced more protracted recoveries than Whites. A protracted recovery was also apparent in that African American participants did not experience the same practice effect at 7 days post-concussion on motor processing speed as did White participants. Typically, practice effects are reported on such tests, and a lack of such an effect might indicate increased neurocognitive vulnerability for that group (Shuttleworth-Edwards, Smith, & Radloff, 2008). Such subtle cross-cultural differences may be attributable to differences in SES, test-taking familiarity, language, or cultural context. However, given that the interactions between race/ethnicity and time were not significant and that differences in only the processing speed composite were supported, this finding must interpreted with caution. Moreover, the results for the RCE analyses involved limited effect sizes and may have been due to chance or been influenced by the interdependent nature of the RCE outcomes. For example, someone with two or more RCEs at 7 days post-concussion is also likely to have had two or more RCEs at 2 days post-concussion.

An alternative and more controversial explanation for the racial–ethnic differences in post-concussion neurocognitive test performance reported in the current study offered by researchers alludes to potential differences in cognitive reserve between different racial–ethnic groups (e.g., Lynn & Holmshaw, 1990; Mehta et al., 2004). The cognitive reserve hypothesis may offer some explanation of why education and literacy levels seem to decrease the gap in neurocognitive performance between different racial and cultural groups (Stern, Albert, Tang, & Tsai, 1999). This hypothesis, which states that higher education and cognitive ability may mitigate functional decrements associated with cerebral injury or disease, has been posited to serve as a neuroprotective factor in cognitive deterioration due to head trauma (Kesler, Adams, Blasey, & Biger, 2003). Early childhood cognitive performance, literacy, and adult occupation have all been suggested to contribute to cognitive reserve (Mehta et al., 2004). As such, cognitive reserve may play a more significant role in explaining potential differences in neurocognitive performance following a concussion than race/ethnicity. In the current study, there may have been a subtle difference in the quality of education for the African American group that influenced their vulnerability in terms of cognitive reserve, but only in conjunction with the additional vulnerability from a concussive injury. Given that the concussions in the current study were fairly mild, moderate to severe concussions may result in even greater post-injury vulnerability than reported in this study.

Test-taking conditions at post-concussion involved the individual student-athlete one-on-one with a sports medicine professional, whereas baseline tests were administered in small groups. This change in testing environment coupled with racial socialization (most of the sports medicine professionals were White) may have resulted in a change in confidence and comfort among African American participants during the post-concussion tests (McKay, 2003). It is important to caution the reader that the empirical support for differences in vulnerability in the current study was limited to motor processing speed learning effects and the increase in risk for one or more RCEs at 7 days post-concussion. However, regardless of the underlying reason, the difference in post-concussion RCEs at 7 days post-concussion and lack of a practice effect on processing speed between African American and White athletes reported in the current study are both disconcerting and in need of further research.

Limitations

The current study had several limitations. The study included a sample that comprised mostly men and American football players. As such, the current study’s findings may have limited application to women and athletes from other sports. The researchers also assumed that participants were honest in reporting their concussion symptoms. Other variables such as SES, reading level, quality of education, educational level, and acculturation level may have confounded the results and were not assessed directly in the current study.

Historically, neurocognitive testing has been scrutinized by researchers and clinicians for purported test-bias as well as a general failure to account for differing cultural and educational experiences such as SES and reading levels (Ferraro & McDonald, 2005; Kennepohl, Shore, Nabors, & Hanks, 2004; O’Bryant, O’Jile, & McCaffrey, 2004; Teng & Manly, 2005). Mehta and colleagues (2004) assessed health, SES, and reading levels as possible explanatory factors to account for differences in cognitive performance on the Modified Mini-Mental State (3MS) Examination and the Digit Symbol Substitution (DSS) test in a sample of older African American and White adults. The African American adults had lower unadjusted scores than Whites; however, when scores were adjusted for reading level and SES, these variables accounted for 86% of the score difference on the 3MS and 64% on the DSS. In their cross-cultural research of black and white southern Africans, Shuttleworth-Edwards and colleagues (2004) reported that low quality of education was the most influential predictor of lower WAIS-III performance. Given these previous findings and the lack of objective measures of potential confounding variables in...
the current study, the results may have been limited by subtle differences in SES, educational level, quality of education, and/or reading level rather than race/ethnicity per se.

Another confounding factor that may have limited the assessment of neurocognitive performance in the current study is the level of acculturation. African Americans who are less acculturated (to other, in this case, White cultural values, beliefs, and practices) may be less familiar with potential content and context in neurocognitive tests and therefore perform lower and at slower speeds on such tests than their more acculturated counterparts. While controlling for potential confounding factors including age, gender, years of education, and SES, Kennepohl and colleagues (2004) reported that African Americans with low levels of acculturation performed lower on neurocognitive tests than African Americans with higher levels of acculturation. Nell (1999) suggested that test sophistication, negative attitudes toward culturally incongruent tests, and reduced test-taking speed may underlie the effects of acculturation on neurocognitive test performance. In summary, acculturation, which was not measured in the current study, may have influenced neurocognitive performance. It is important to note that the researchers are currently analyzing data from a follow-up study that examines the role of acculturation and SES in computerized neurocognitive concussion testing outcomes.

Conclusion

The results of the current study support two distinct findings. First, the results indicated that there were no significant differences in computerized neurocognitive performance as assessed by the ImPACT test between African American and White athletes at baseline. This finding suggests that at baseline the ImPACT test is a measure that is both culturally equivalent and construct valid for use with these two racial/ethnic groups. As such, the creation of separate baseline ImPACT normative values for African Americans for use in neurocognitive concussion testing is not warranted. Second, the results suggest that there were subtle cross-cultural differences between African American and White athletes at the post-concussion ImPACT evaluation. Specifically, the lack of a demonstrated trend toward a practice effect in motor processing speed among African American participants at 7 days post-concussion suggests that this group may be vulnerable to pronounced clinical symptoms and neurocognitive decrements following concussion. The findings also indicated that at 7 days post-concussion African American athletes were 2.4 × more likely to incur at least one RCE than White athletes. However, this finding should be interpreted cautiously, as it was neither replicated in the other RCE measures nor the baseline or post-concussion neurocognitive composite scores, and the RCE outcomes were statistically interdependent. None the less, these tentative though statistically significant post-concussion findings warrant attention from both clinicians and researchers who use computerized neurocognitive testing as part of a comprehensive concussion management program. Specifically, clinicians should be vigilant for potential differences in post-concussion neurocognitive outcomes between African American and White athletes, as these differences may be indicative of underlying neurocognitive vulnerability following injury. Finally, researchers need to explore further the myriad factors such as SES, quality of education, acculturation, reading level, and cognitive reserve that may have influenced and limited the current study’s findings; as well as include athletes representing other racial–ethnic groups.

Conflict of Interest

None declared.

References


