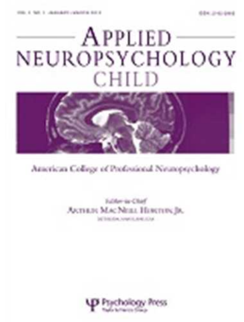

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Neuropsychological Test Performance of Youth Football Players at Different Positions: A Comparison of High and Low Contact Players

Applied Neuropsychology: Child

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Abstract

The aim of this study was to examine the effects of head impact frequency on the neuropsychological test results of football players who participate in different positions on the team. Based on the biomechanical measures of head impact frequency reported in high school football, a High Contact group (n=480) consisting of offensive and defensive linemen was compared with a Low Contact group (n=640) comprised of receivers and defensive backs. The results revealed that the High Contact group obtained poorer performances on the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) on three Composite scores (Verbal Memory, Visual Motor Speed, Impulse Control) and the Total Symptom score compared to the Low Contact group. The present study is the first, to date, to report differences in the neuropsychological test performances of athletes who participate in high and low contact football positions. The findings raise tentative concerns that youth football players exposed to repetitive head trauma, including subconcussive impacts, may be at risk for lowered neuropsychological functioning and increased symptoms. In view of the preliminary nature of this investigation, more research into the effects of head trauma frequency in youth football is strongly recommended.

Neuropsychological Test Performance of Youth Football Players at Different Positions: A Comparison of High and Low Contact Players

Introduction

Sports-related concussions have become a magnet for increasing scrutiny by clinicians, researchers, and popular media alike, largely due to the highly publicized cases of concussion damage in National Football League players (Fainaru-Wada & Fainaru, 2013). In recent years, the widespread participation in high school and collegiate sports has also attracted attention due to higher concussion rates in sport, with a significant increase from 23% to 57% from 2005 through 2012 (Rosenthal, Foraker, Collins, & Comstock, 2014). While the frequency of concussion varies from sport to sport, football consistently commands one of the highest rates of concussion at high school and collegiate levels compared to other sport activities (Jinguji, Krabak, & Satchell, 2011; Marar, McIlvain, Fields, & Comstock, 2012; Noble & Hesdorffer, 2013).

Within football, the rate of concussive injuries appears to vary depending on which position the athlete plays. An 8-year (1975-1982) investigation of 49 college teams found that the highest frequency of game-related concussions on defense were reported by defensive backs, while among the offensive players, running backs reported the most game-related concussions (Buckley, 1988). A study of concussions in college football players by Collins and his associates (2005) indicated that quarterbacks and tight ends reported the highest rates of prior concussion. A review of 16 years of National Collegiate Athletic Association (NCAA) injury surveillance data for football found that

(1) offensive players received more concussions than defensive players; and (2) quarterbacks and running backs had the highest number of concussions, while offensive and defensive linemen had the lowest number of concussions (Dick et al., 2007). Among high school football players, linebackers sustain the highest proportion of concussion injuries among the defensive players, while running backs have the highest proportion of concussions of players in offensive positions (Gessel, Fields, Collins, Dick, & Comstock, 2007; Powell & Barber-Foss, 1999). The concussion rates in high school and college football suggest, in general, that offensive skill players (running backs and quarterbacks) and linebackers may experience more concussions than players in other positions.

Recent biomechanical technology has been employed to quantify the magnitude and frequency of head impacts sustained by football players in different positions. Researchers at the University of Oklahoma placed the Head Impact Telemetry (HIT) System in the helmets of 40 college football players and 16 high school football players to measure all head impacts from practices and games during the 2005 football season (Schnebel, Gwin, Anderson, & Gatlin, 2007). Besides noting that college players sustained high-level impacts more frequently than high school players, the investigators found that skill position players (quarterbacks, running backs, wide receivers, cornerbacks, and safeties) in high school and college received a greater percentage of high level impacts (60-98g) than linemen. In contrast, linemen sustained the highest number of impacts, but most were of relatively low magnitude (20-30g). A similar HIT approach to analyze head impacts incurred by high school football players found that offensive skill players (quarterback, receiver, tight end, running back, fullback) sustained the greatest magnitude of linear acceleration after an impact (Broglio et al., 2009).

Defensive and offensive linemen, in contrast, sustained the lowest magnitude impacts but had the most impacts during games and practices. A four-year investigation, using the HIT system of helmet-mounted accelerometers with high school football players, found that linemen sustained the highest number of impacts (>15g) per season, while the lowest number of impacts were attained by receivers, corner backs and safeties (Broglio et al., 2011).

With accelerometers embedded in the helmets of college football players, Mihalik, Bell, Marshall, and Guskiewicz (2007) reported that offensive linemen had the highest frequency of recorded impacts, while offensive backs sustained the highest magnitude impacts. Crisco and his associates (2010) also used HIT instrumentation with college football players in one season and found that linemen and linebackers had a greater number of impacts per practice and game than players at other positions. Crisco et al. (2012) later reported that running backs consistently sustained the greatest impact magnitudes of head trauma. Similarly, Funk, Rowson, Daniel, and Duma (2012) examined the HIT data of college football players over a 4-year period and reported that linemen sustained the highest number of head impacts, while skill position players had a higher number of more severe head impacts (>100g). In summarizing the research utilizing HIT with high school and collegiate football players, it appears that offensive skill players are likely to sustain more severe head impacts, while linemen have the highest number of head impacts in football.

Comparing the outcomes of head impact across different football positions in college, Baugh and her associates (2015) found no differences between position groups in the number of diagnosed concussions, but noted that offensive linemen had higher amounts of undiagnosed concussions and “dings” than other position players. Moreover, the authors noted that offensive linemen, who experience frequent but low magnitude head impacts, develop more post-impact symptoms than other position players. The research literature that have compared the head trauma frequencies of football players in varied positions is increasing but, thus far, there are no known studies examining the neuropsychological test data of youth football athletes playing in different team positions. The primary aim of this research was to compare the baseline neuropsychological test scores of youth football players in different positions on the team with a focus on the test results of players in high and low contact football positions.

Materials and Methods

This study was reviewed by the Hawaii Pacific Health Research Institute and was determined to be exempt from Institutional Review Board review.

Test Instrument

This study utilized the Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) battery, which has been employed in several studies of concussions among high school athletes (Lovell, 2006). ImPACT is a web-based computerized neuropsychological test battery developed for the assessment of sports-related concussion in youth, collegiate, and professional athletes. The test, which takes about 30 minutes to complete, was administered in small groups of about 20 prior to the season, monitored by certified athletic trainers trained in the standardized administration of the examination. A more complete description of ImPACT can be found elsewhere (Lovell, 2012). ImPACT produces five neurocognitive composite scores, including Verbal Memory, Visual Memory, Visual Motor Speed, Reaction Time, and Impulse Control. The testing also yields a Total Symptom score, based on the ImPACT Post-Concussion Symptom Scale that consists of 22 commonly reported symptoms, e.g., headache, dizziness. The test provides self-reported demographic and health information, such as age, sex, years of education, native language, sport played, prior concussion, and history of seizures, psychiatric illness, learning disability, attention deficit disorder, psychiatric illness or seizures.

Protocol

All athletes were administered the ImPACT test prior to the start of their sport season. The baseline testing was conducted in groups of approximately 20 athletes, monitored by an athletic trainer trained in the standard administration of this computerized neuropsychological test battery. Although the baseline testing was conducted before season play, it was assumed that the athletes participated in football in the past and experienced varying degrees of contact and head trauma.

Procedure

This research design was similar to previous investigations of repetitive head impacts that compared athletes in contact sports, such as football and soccer, with athletes in non-contact sports, like track and tennis (McAllister et al., 2012; Stephens, Rutherford, Potter, & Fernie, 2010; Tsushima, Siu, Arnold, & Oshiro, 2016). The present study operationally defined a High and a Low Contact group according to the frequency of head impacts reported in high school football (Broglio et al., 2009; Schnebel et al., 2004). Similar patterns of head impact frequency were noted by Crisco et al. (2010) and Funk et al. (2012) in their HIT evaluations of collegiate players in varied football positions.

Participants

The pool of athletes were 4,952 males, ages 13 to 18 years, from 65 schools in Hawaii. Of these, 4,790 athletes met the following inclusionary criteria: native language of English and valid ImPACT baseline test results. Excluded from the study were 162 who indicated that English was not their native language, and 337 who had invalid profiles which were automatically identified by the online ImPACT version that incorporates the following cut-off scores: Impulse Control Composite score ≥30, X's and O's–Total Incorrect >30, Word Memory–Learning Percent Correct <69, Design Memory–Learning Percent Correct <50, and Three Letters–Total Letters Correct <8 (Lovell, 2012). There were 2,173 athletes who participated in football. Football position data were missing for 423. Additionally, 630 football players were excluded who were not in the High Contact (offensive and defensive linemen) or Low Contact (receivers and defensive backs) groups. The High Contact group was comprised of 212 offensive linemen and 268 defensive linemen, who are known to have the highest frequency of head impacts, while the Low Contact group consisted of 347 receivers and 293 defensive backs, who have the lowest frequency of head impacts.

Data Analysis

Descriptive statistics were summarized by means and standard deviations along with medians and ranges for continuous variables and by frequencies and percentages for categorical variables. The two contact groups were compared in terms of age and six ImPACT scores (Verbal Memory, Visual Memory, Visual Motor Speed, Reaction Time, Impulse Control, and Total Symptom). The normality of age and ImPACT scores was assessed via the Shapiro-Wilk test and Smirnov test. Due to non-normal distributions, non-parametric statistics, namely, the Wilcoxon Rank Sum tests, were employed to compare ages and scores of the High and Low Contact groups. A chi-square test was used to compare percentages of prior concussion of the two contact groups. All data analyses were performed in SAS 9.3 (SAS Institute Inc., 2011). A two-tailed *p*-value of less than 0.05 was regarded as statistically significant.

Results

Among the High Contact athletes, 69 (14.4%) reported having a prior concussion, while 118 (18.4%) of the Low Contact players reported a prior concussion. The percentage difference in prior concussions was not statistically significant ($\chi^2[1]=3.25$, $p=0.07$). The data pertaining to the age and ImPACT scores of the High and Low Contact Groups appear in Table 1. The High Contact group obtained significantly poorer ImPACT Composite scores in Verbal Memory ($\chi^2[1]=9.90$, $p=0.002$), Visual Motor Speed ($\chi^2[1]=8.97$, $p=0.003$), Impulse Control ($\chi^2[1]=14.05$, $p=0.0002$), and Total Symptoms ($\chi^2[1]=11.85$, $p=0.0006$). No significant differences were seen between the two groups in age, Visual Memory, and Reaction Time.

Discussion

The present study represents, to our knowledge, the first effort to evaluate the consequences of frequent head impacts on youth football players in different positions by examining the neuropsychological test scores of a large sample of athletes in different positions of the football team. The data analysis focused on two groups of football positions, based on the reported frequency of head impacts found at different positions (Broglio et al., 2009), with the assumption that more neuropsychological decline occurs at positions where more impacts occur. The results revealed that the High Contact group of offensive and defensive linemen obtained poorer results on three ImPACT Composite scores (Verbal Memory, Visual Motor Speed, Impulse Control) and reported more symptoms than the Low Contact group comprised of receivers and defensive backs. The findings are consistent with prior research that revealed an increase in neurological symptoms associated with head impact frequency (Baugh et al., 2015), but are at odds with a HIT study that found no relation between neuropsychological test results and the total number of head impacts of college football players over one season (Gysland, Mihalik, Register-Mihalik, Trulock, Shields, & Guskiewicz, 2012).

While high magnitude collisions and concussions capture much of the attention of football fans and sports media, frequent lower intensity head trauma cannot be ignored or taken lightly. Researchers have noted that high school football players sustain a greater number of head impacts compared to other sports, like soccer and ice hockey (Broglio et al., 2011). In football, non-concussive hits can occur on nearly every play, especially for linemen who encounter constant helmet-to-helmet crashes (Talavage et al., 2013). A high school football player may experience over 2,000 subconcussive blows during the course of a single season (Broglio et al., 2011). The consequences of repetitive head blows in sports are not insignificant. Investigators have found that youth athletes in contact sports, like football, display poorer performances in neurocognitive tasks than non-contact athletes, such as in basketball, baseball and track (McAllister et al., 2012; Tsushima et al., 2016). However, it should be noted that Stephens and his associates (2010) found no differences in the neuropsychological test performances of soccer, rugby, and non-contact players (e.g., swimming, tennis, cricket). Nonetheless, in recent years the interest in repetitive head impacts has grown, with concerns that cumulative head trauma, including subconcussive blows, can seriously affect brain functions (Bailes, Petraglia, Omalu, Nauman, & Talavage, 2013; Graham, Rivara, Ford, & Spicer, 2014).

Without quantifiable measures of head trauma as provided by the use of head impact telemetry, it is difficult to directly study repetitive head impacts and their potential effects. The present investigation provided an indirect option by comparing a group of athletes who are known to incur high frequencies of head impacts with athletes who reportedly have a low frequency of head impacts. The findings from this approach could be helpful in assessing the variable risk of repetitive head trauma in football players. Further research on the effects of head impact frequency utilizing the present methodology should be considered.

Limitations

The methodological flaws of this study should be recognized when interpreting these findings (1) In youth football some athletes play more than one position. We were unable to identify if any of the players played in more than one position or how much time they may have played in different positions. An athlete who played in both offensive and defensive line positions could have increased his exposure to impacts and the risk for injury. (2) The neuropsychological test measures in this research represent only the handful of neurocognitive functions contained in the ImPACT battery, and do not represent the wide range of neuropsychological variables found in a comprehensive test battery. Further investigation employing a broader set of neurocognitive measures is desired. (3) This retrospective study was not able to assess other variables that could affect neuropsychological functioning, such as school aptitude and test effort.

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Author Disclosure Statement

No competing financial interests exist for any of the five authors.

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Table 1. Age and ImPACT scores of High and Low Contact Groups

Variable	High Contact Group (n=480)	Low Contact Group (n=640)	Chi-square	*p* value
	mean (SD), median [range]	mean (SD), median [range]		
Age	14.92 (1.17), 15.00 [13.00-18.00]	14.92 (1.18), 15.00 [13.00-18.00]	0.0032	0.96
Impulse Control Composite Score	8.18 (5.21), 7.00 [0.00-29.00]	7.11 (4.88), 6.00 [0.00-27.00]	14.05	0.0002*
Verbal Memory Composite Score	80.97 (10.63), 82.00 [46.00-100.0]	82.95 (10.15), 84.00 [53.00-100.0]	9.90	0.002*
Visual Memory Composite Score	72.66 (13.58), 74.00 [36.00-100.0]	74.27 (12.97), 75.00 [38.00-100.0]	3.63	0.057
Reaction Time Composite Score	0.65 (0.10), 0.64 [0.42-1.46]	0.64 (0.10), 0.63 [0.41-1.37]	2.05	0.16
Total Symptom Score	7.00 (10.65), 3.00 [0.00-74.00]	5.04 (8.44), 2.00 [0.00-87.00]	11.85	0.0006*
Visual Motor Composite Score	33.15 (6.75), 32.83 [12.00-53.50]	34.32 (6.57), 34.09 [12.35-50.63]	8.97	0.003*

*statistically significant ($p<0.05$)