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Greenberg, S. A., & Shuman, D.W. (2007). When worlds collide: Therapeutic and forensic roles. *Professional Psychology: Research and Practice, 38* (2), 129-132.

Johnston, J. R., & Campbell, L. E. G. (1988). *Impasses of divorce: The dynamics and resolution of family conflict.* New York, NY: Free Press.

Specialty Guidelines for Forensic Psychologists (1991; http://www.ap-ls.org/links/currentforensicguidelines.pdf)

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Short-term and Long-term Effects of a Single Concussion and Age on the Neuropsychological Test Performance of High School Athletes

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Abstract

The short-term and long-term effects of a single sports-related concussion on the neuropsychological functioning of high school athletes of different ages were examined by administering the Immediate Post-concussion Assessment and Cognitive Testing (ImPACT) to 639 high school athletes (444 boys, 195 girls). The athletes were divided into one of three concussion groups: No Concussion, or those with no prior concussion (n=538); Recent Concussion, or those with one prior concussion followed by testing within 30 days (n=63); and Remote Concussion, or those with one prior concussion followed by testing beyond 30 days

(n=38). The participants were also grouped by ages 12-13, 14, 15, 16, and 17-18. The results of a two-way MANOVA were significant for the Concussion, Age, and Concussion by Age interaction effects, with small effect sizes. Recent Concussion athletes had significantly lower Verbal Memory scores than Remote Concussion athletes, and the 15 year-old Remote Concussion athletes scored significantly lower in Visual Memory than the 17-18 year-old Remote Concussion athletes. The results tentatively suggest that a single concussion can result in memory deficits for up to 30 days after a mild head injury in sports. In addition, the memory functioning of younger high school athletes appears to recover more slowly than in their older counterparts in high school. The findings may have important implications for the classroom learning of concussed athletes, particularly the younger players.

Short-term and long-term effects of a single concussion and age on the neuropsychological test performance of high school athletes

A number of large scale studies and surveys suggest that traumatic brain injury (TBI) among young athletes is a prominent health problem. According to the Centers for Disease Control and Prevention, approximately 300,000 sports and recreation-related TBIs occur each year, but this included only TBIs that involved a loss of consciousness (Thurman, Branche, & Sniezek, 1998). Since other studies suggest that loss of consciousness occurs in about 8 to 19% of sports-related TBIs, a more accurate estimate may be that 1.6 million to 3.8 million TBIs occur in sports and recreation activities each year (Langlois, Rutland-Brown, & Wald, 2006). A CDC report of non-fatal TBI from sports and recreation activities between 2001 and 2005 indicated that children and youth ages 5 to 18 had the highest rates of sports and recreation-related TBI, accounting for 2,400,000 emergency department visits annually (Centers for Disease Control and Prevention, 2007).

In organized sports high school athletes represent the largest group of participants who are at risk for sustaining a sports-related concussion, or mild traumatic brain injury (mTBI). Approximately 62,816 cases of mTBIs occur each year in high school athletic activities (Powell & Barber-Foss, 1999), or an overall rate of 17.15 concussions per 100,000 athlete-exposures (Schulz et al., 2004). The prevalence of concussion among high school athletes may even be higher than reported in the literature because of the substantial numbers who fail to report concussions (McCrea, Hammeke, Olsen, Leo, & Guskiewicz, 2004).

Short-term and long-term outcome of concussion

Few studies have provided objective test data on the immediate neuropsychological effects after mTBI in high school sports. Using the Standardized Assessment of Concussion (SAC), a brief neurological and neuropsychological screening measure, McCrea, Kelly, Christopher, Cisler, & Berger (2002) found that significant neurocognitive impairment was detected 15 minutes after head injury, but nearly all concussed high school and college football players (n=91) displayed full recovery with the SAC within two days after the head injury. Other studies have noted a longer recovery period immediately after a concussion than control subjects. Concussed high school athletes performed more poorly on memory tasks (Field, Collins, Lovell, & Maroon, 2003) and on measures of attention and concentration (Moser, Schatz, & Jordan, 2005) seven days after their head injury than non-concussed athletes.

According to various investigators, the long-range effects of concussion among high school sports participants appear to be negligible. In a study of 60 male and 40 female high school athletes, no differences between athletes with or without prior concussion were noted on a brief battery of neuropsychological tests (Barr, 2003). Similar findings were reported in a study involving 43 high school athletes tested on the Immediate Post-concussion Assessment and Cognitive Testing (ImPACT). Those with a history of prior concussion did not differ from those with no concussion history on memory testing, reaction time or processing speed (Lovell, Collins, Iverson, Johnston, & Bradley, 2004). In a meta-analysis of 21 studies of sports-related concussion using high school athletes and beyond, no residual neuropsychological impairments were noted when testing was completed beyond seven days post-injury (Belanger & Vanderploeg, 2005). In contrast, a larger study of 223 high school athletes revealed that athletes with recent concussions performed significantly worse on the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS) than those with no history of previous concussion (Moser et al., 2005). Moreover, those with a history of two or more previous concussions exhibited subtle yet significant prolonged neuropsychological effects.

Outside of the athletic arena, the long-term outcome after an mTBI among children also seems insignificant, with resolution of post-concussion symptoms and cognitive deficits within two or three months after injury (Carroll et al., 2004; Kirkwood, Yeates, Taylor, Randolph, McCrea, & Anderson, 2008). In reviews of outcome studies between 1970 and 1998, Satz and his associates concluded that mild head injury (mHI) in children may result in mild transitory impairment in cognitive functioning, but no lasting impact on academic or psychological functioning (Satz, 2001; Satz, Zaucha, McCleary, Light, Asarnow, & Becker, 1997). While researchers found that mHI before age 10 resulted in no significant cognitive and academic effects, long-term problems in psychosocial functions were noted (McKinlay, Dalrymple-Alford, Horwood, & Fergusson, 2002). A review of the literature regarding the neurobehavioral outcomes of mHI in children and adolescents also found little evidence of persistent cognitive deficits, but noted post-concussive somatic symptoms, such as headache and lethargy, that last months or even years (Yeates & Taylor, 2005). In addition, a follow-up study of 526 head injured children indicated that 40 to 50% exhibited moderate disability with behavioral and learning difficulties two years after mHI (Hawley, Ward, Magnay, & Long, 2004). Finally, in a recent report of neuropsychological functioning 23 years after mTBI, investigators found that children sustaining complicated mTBI were more prone to developing chronic mild neuropsychological dysfunction than adults with similar head injuries (Hessen, Nestvold, & Anderson, 2007). These differing results warrant further examination of the long-range effects of mHI among adolescents.

Age and concussion

Younger participants in sports may be at higher risk for concussions as a result of less developed, more susceptible brains (Giza & Hovda, 2004; Theye & Mueller, 2004). The increased vulnerability may be the result of a greater head-to-body ratio, thinner cranial structure, and decreased mylenation, thus providing less protection to the developing brain (McKeever & Schatz, 2003). The young are prone to more structural injury, e.g., subdural hematoma, and cerebral swelling after minor head injury that could result in a prolonged recovery period (McCrory & Bercovic, 1998). Additionally, high school athletes frequently believe that the injury is not serious enough to report, or fail to recognize that a concussion has even occurred (McCrea et al., 2004; Williamson & Goodman, 2006). This lack of awareness that a concussion has occurred may have serious consequences, including (1) misunderstanding post-concussion sequelae, such as headaches, dizziness and irritability, that disrupt a student athlete's academic performance and social relationships; (2) the possibility of a second impact syndrome, i.e., a second head trauma while still recovering from the initial concussion, causing serious neurological consequences; and (3) the cumulative effects of repeated concussions (Theye & Mueller, 2004). In a large survey of certified athletic trainers, high school football players had a concussion incidence rate that was more than twice that of Division I college football players (Guskiewicz, Weaver, Padua, & Garrett, 2000), although two recent large scale studies of various sports at high schools and colleges reported that the overall concussion rate was higher in collegiate sports than among high school athletes (Gessel, Fields, Collins, Dick, & Comstock, 2007; McCrea et al., 2002). In soccer, high school players seem to sustain concussions at a greater rate than collegiate soccer players. Concussion rates among high school soccer players are estimated to be about one per 2,000 athletic exposures (Boden, Kirkendall, & Garrett, 1998), while concussion rates among college soccer players are about one per 3,000 athletic exposures (Green & Jordan, 1998).

Despite these noteworthy statistics, limited attention has been given to age factors among high school athletes who have sustained a concussion (Gessel et al., 2007; McKeever & Schatz, 2003). Interest in younger student athletes is warranted in view of evidence that suggests that high school athletes have a recovery pattern that differs from older athletes following head injury. In a study of 19 high school and 35 college athletes who received a concussion during athletic competition, high school athletes with concussion had prolonged memory dysfunction compared with college athletes with concussion (Field et al., 2003). A sample of 64 high school athletes exhibited memory deficits at least seven days after mild concussion, as compared to college and professional athletes whose neuropsychological recovery occurred two to five days post-injury (Lovell et al., 2003). Similar findings were reported in a comparison of 28 high school athletes and 30 National Football League players five days post-injury, with the high school athletes demonstrating a slower recovery rate in reaction and memory than NFL players (Pellman, Lovell, Viano, & Casson, 2006). However, results in three other age-related neuropsychological investigations reported no significant age factor in concussed young athletes. No differences appeared on the Standardized Assessment of Concussion (SAC) between 2385 high school and college football players immediately after concussion, or at 15 minutes, 48 hours, or 90 days after injury (McCrea et al., 2002). No age differences on the Concussion Resolution Index (CRI), a brief computerized neuropsychological assessment tool, were found among 155 high school and college athletes evaluated one day after a concussion (Broshek et al., 2005). The Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) (Lovell, Collins, Podell, Powell, & Maroon, 2000) was administered to 72 recently concussed high school athletes and 66 non-concussed high school athletes. Age was not a relevant factor in the five ImPACT composite scores (Schatz, Pardini, Lovell, Collins, & Podell, 2006). The varying results were apparently due to the different research designs and neurocognitive tests, and leave the issue of age differences in the response to sport-related concussions unclear.

The present study attempted to examine further the short-term and long-term neuropsychological effects of concussion in high school athletes by comparing the scores of players of different ages with and without a history of prior concussion.

Method

Participants

This retrospective archival study obtained the ImPACT test scores of 639 consecutive high school athletes (444 boys, 195 girls), who were healthy at the time of testing. The student athletes were from four public high schools in Hawaii.

The average age of the total sample was 15.29 years (SD = 1.21). The student-athletes completed an average of 9.43 years (SD = 1.25) of schooling. The average days post-injury was 155.71 (SD = 294.32).

Of the participants, 101 (15.8%) reported one previous concussion. The largest portion of the athletes was football players (56.3%). Other sports included basketball (14.1%), softball (9.4%), wrestling (8.8%), cheerleading (7.0%), soccer (0.5%), volleyball (0.3%), track and field (0.2%), and boxing (0.2%).

The athletes were divided into one of three concussion groups: No Concussion, or those with no prior concussion (n = 538; 373 boys, 165 girls); Recent Concussion, or those with one prior concussion followed by testing within 30 days (n = 63; 46 boys, 17 girls); and Remote Concussion, or those with one prior concussion followed by testing beyond 30 days (n = 38; 25 boys, 13 girls). The participants were also grouped by ages 12-13, 14, 15, 16, and 17-18.

Excluded from the study were a small number of athletes who reported two or more prior concussions.

Materials and Procedures

The participants were administered the ImPACT battery as part of an ongoing program establishing baseline or pre-injury neuropsychological test data of athletes to assist the athletic department staff in making return-to-play decisions after the occurrence of a sports-related concussion. Data were also collected regarding the athlete's concussion history, although information about the severity of the head trauma and the duration since the prior concussion was not obtained.

The computerized neuropsychological test was administered to each athlete by an athletic trainer trained in the administration of ImPACT. Version 2.0 of ImPACT consists of six individual test modules that measure different cognitive abilities. The four standard ImPACT composite scores were used for this study, including Verbal Memory, Visual Memory, Motor (or Processing Speed), and Reaction Time.

The scores of the No Concussion group were obtained in baseline testing prior to the sports season, while the scores of the Recent and Remote Concussion groups were obtained in follow-up re-testing after a mild head injury. To minimize practice effects, ImPACT employs several alternate forms (Iverson, Lovell, & Collins, 2003).

Statistics

The data were analyzed using descriptive and multivariate approaches. First, ANOVAs were employed to examine whether the three Concussion groups differed in terms of their age and education. Second, an ANOVA was conducted to evaluate differences between the five Age groups regarding days post-injury. Finally, the four ImPACT composite scores of the Concussion and Age groups were compared by employing a two-way MANOVA. All analyses were done using SPSS Version 17.0, with GLM MANOVA. The MANOVA design allowed an analysis of ImPACT test scores of athletes with different concussion and age histories, and also permitted an analysis of possible interaction effects between concussion and age.

Results

Table 1 presents the means and standard deviations of the age, education, and days post-injury for the three Concussion groups. Although the between-group differences were very small, the Concussion groups differed statistically significantly on age (p=.003) and education (p=.054). Tukey pair-wise comparisons showed that the No Concussion group was significantly younger than the Recent Concussion group (p = .027) and the Remote Concussion group (p=.041). The pair-wise comparisons for education of the Concussion groups were not significant. No difference between the five Age groups was found regarding days post-injury.

A two-way MANOVA was performed to examine differences on the four ImPACT composite scores between the three Concussion groups and between the five Age groups. Tables 2 and 3 present, respectively, the means and standard deviations of the ImPACT scores for the three Concussion groups and five Age groups. The MANOVA results were significant for the Concussion [*Wilks' Lambda F* (8,1242) = 2.03; p = .040], Age [*Wilks' Lambda F* (16,1897.824) = 2.62; p = .0001], and Concussion by Age interaction effects [*Wilks' Lambda F* (32,2291.73) = 1.58; p = .020]. Effect sizes were small, as the *partial eta squared* were, respectively, .013, .017, and .020.

Follow-up ANOVAs showed significant differences between the Concussion groups on Verbal Memory (p=.038); significant differences between the Age groups on Visual Memory (p=.004), Motor (p=.0001) and Reaction Time (p=.002),and significant Concussion by Age interactions on Verbal Memory (p = .038) and Visual Memory (p = .013).

Further analyses with Tukey pair-wise comparisons found that Recent Concussion athletes had significantly lower Verbal Memory scores than Remote Concussion athletes (p=.032). No significant pair-wise difference between the Age groups was found on Verbal Memory, but on Visual Memory, 14 year-olds had lower scores than 17-18 year-olds (p=.046) and 15 year-olds had lower scores than 17-18 year-olds (p=.012). For the Motor score, 12-13 year-old had lower scores than 15 year-olds (p=.017), 16 year-olds (p=.001), and 17-18 year-olds (p=.001); and 14 year-olds had lower scores than 16 year-olds (p=.024) and 17-18 year-olds (p=.008). For the Reaction Time score, 14 year-olds had poorer scores than 16 year-olds (p=.040) and 17-18 year-old (p=.006).

There were no significant differences in the Visual Memory scores of the 15 year-olds and 17-18 year-olds in the No Concussion and Recent Concussion groups. However, 15 year-old Remote Concussion athletes (M=65.25, SD=12.77) scored significantly lower in Visual Memory than 17-18 year-old Remote Concussion athletes (M=80.58, SD=11.82) (p = .015).

Discussion

The results of this study indicated that Recent Concussion athletes who were tested within 30 days of their head injury had lower Verbal Memory scores than Remote Concussion athletes. No other differences between the three Concussion groups were noted on the ImPACT composite scores. The findings suggest that a single concussion among high school athletes can result in temporary deficits in certain memory functioning, with a return to normal test scores beyond 30 days of injury.

While past studies have observed neuropsychological dysfunction among high school athletes up to seven days after an mTBI (Field et al., 2003; Moser et al., 2005), the present study examined a longer "short-term" post-injury period and found lowered memory scores, albeit a small effect size, 30 days post-concussion. The results are at odds with the meta-analytic findings of Belanger and Vanderploeg (2005) that reported full neuropsychological recovery 7-10 days after a sports-related concussion by high school and older athletes. In view of the practice of allowing athletes to return to play if symptom-free for one to two weeks (Echemendia, 2006), the present data suggest that some student-athletes do not completely recover within 30 days and deserve further monitoring and medical follow-up to insure that they have recovered fully before being allowed to play again.

The term "mild" in describing concussions as mTBI may convey the incorrect impression that a closed head trauma has trivial effects on the high school athlete. As can be seen by the current and past research, a blow to the head in sports can effect notable memory deficits, if only for a short period after the injury. Consequently, concussed student-athletes may have difficulties in classroom learning for several days and even a few weeks, which could seriously compromise their school performance. Future concussion research that evaluates classroom performance would provide valuable information about the short-term impact from athletic head trauma.

The significant Age differences on the Verbal Memory, Visual Memory, and Motor composite scores were not unexpected, given the well-known literature on developmental progression during adolescence. The data stress the importance of employing specific age norms, such as are available with ImPACT (Lovell et al., 2000), when evaluating the neuropsychological test scores of high school athletes.

The significant Concussion by Age interaction on Visual Memory tentatively suggests that younger athletes, i.e., 15 year-olds, recover more slowly than older 17-18 year-old athletes after an mTBI. The non-significant difference between those younger than age 15 and the 17-18 year-olds was a statistical artifact due to the inadequate sample sizes in the 12-13 year-old group ($n = 2$) and the 14 year-old group ($n = 3$). The results are consistent with past reports that described the greater vulnerability of younger children to mild head injury compared to older children and adults (Giza & Hovda, 2004; Theye & Mueller, 2004), and encourage further attention to age factors in sports-related concussion among high school athletes. The present study examined those athletes who had only a single concussion. Concussed athletes invariably return to play and are more susceptible than their non-concussed teammates to a subsequent concussion as a result of their prior mTBI (Guskiewicz et al., 2000; Schulz et al., 2004). Moreover, high school athletes with a history of two or more previous concussions exhibit prolonged difficulties in attention and concentration (Moser et al., 2005) and other persistent cognitive deficits (Collins et al., 1999). The short-term and long-term neuropsychological outcomes of athletes who have more than one concussion also deserve further research attention.

A notable limitation in this study was our reliance on the non-verifiable retrospective self-reports of concussion by the high school athletes. The participants were likely to vary in their ability to recognize relevant concussion symptoms as well as in their willingness to admit to having had a concussion for fear of jeopardizing their playing status (McCrea et al., 2004). Factors such as the type of head trauma, the time frame of the head trauma, and the severity or grade of the concussion were not obtained in the self-reports. The ideal would be to have a prospective research design with on-the-field medical staff that are familiar with the classification of concussion severity immediately evaluate the athlete who suffers an mTBI, and to document the findings in the athlete's medical records. Until such pristine circumstances are attained, studies of large numbers of high school athletes will remain dependent on athletes' self-reports.

The present research focused on the neuropsychological test scores of post-concussion high school athletes, but did not examine other possible sequelae of mTBI, such as somatic complaints, behavioral and psychosocial difficulties, as well as learning problems, that could occur after concussion (Hawley et al., 2004;

Yeates & Taylor, 2005). A study that examines not only neurocognitive functioning but the myriad of ways in which mTBI affects adolescents would be valuable.

The institutions in this research were four public high schools in Hawaii. Little is known about the influence of factors such as geographic region and sociocultural factors on the neuropsychological test performances of student-athletes (Echemendia, 2004; Tsushima, Oshiro, & Zimbra, 2008). In view of the unique geographic location, culture and ethnic composition of the high school athletes in Hawaii, the present results may not be easily generalizable to sports participants on the mainland U.S. Further research on the effects of concussion and age with a diversity of high school athletes across the country is highly desirable.

References

Barr, W.B. (2003). Neuropsychological testing of high school athletes: Preliminary norms and test-retest indices. Archives of Clinical Neuropsychology, 18, 91-101.

Belanger, H.G., & Vanderploeg, R.D. (2005). The neuropsychological impact of sports-related concussion: A meta-analysis. Journal of the International Neuropsychological Society, 11, 345-357.

Boden, B.P., Kirkendall, D.T., & Garrett, Jr., W.E. (1998). Concussion incidence in elite collegiate soccer players. The American Journal of Sports Medicine, 26, 238-241.

Broshek, D.K., Kaushik, T., Freeman, J.R., Erlanger, D., Webbe, F., & Barth, J.T. (2005). Sex differences in outcome following sports-related concussion. Journal of Neurosurgery, 102, 846-863.

Carroll, L.J., Cassidy, J.D., Peleso, P.M., Borg, J., von Holst, H., Holm, L.,...Pèpin, M. (2004). Prognosis for mild traumatic brain injury: Results of the WHO Collaborating Centre Task Force on Mild Traumatic Brain Injury. Journal of Rehabilitation Medicine, Suppl. 43, 84-105.

Centers for Disease Control and Prevention (2007). Non-fatal traumatic brain injuries from sports and recreation activities – United States, 2001-2005. MMWR, 56, 733-737.

Collins, M.W., Grindel, S.H., Lovell, M.R., Dede, D.E., Moser, D.J., Phalin, B.R.,...McKeag, D.B. (1999). Relationship between concussion and neuropsychological performance in college football players. Journal of the American Medical Association, 282, 964-970.

Echemendia, R.J. (2004). Cultural aspects of neuropsychological evaluations in sports. In M.R. Lovell, R.J. Echemendia, J.T. Barth, & M.W. Collins (Eds.), Traumatic brain *injury in sports* (pp. 435-442). Lisse, The Netherlands: Swets & Zeitlinger.

Echemendia, R.J. (2006). Return to play. In R.J. Echemendia (Ed.), Sports neuropsychology (pp. 112-128). New York: The Guilford Press.

Field, M., Collins, M.W., Lovell, M.R., & Maroon, J. (2003). Does age play a role in recovery from sports-related concussion? A comparison of high school and collegiate athletes. Journal of Pediatrics, 142, 546-553.

Gessel, L.M., Fields, S.K., Collins, C.L., Dick, R.W., & Comstock, R.D. (2007). Concussions among United States high school and collegiate athletes. Journal of Athletic Training, 42, 495-503.

Giza, C.C., & Hovda, D.A. (2004). The pathophysiology of traumatic brain injury. In M.R. Lovell, R.J. Echemendia, J.T. Barth, & M.W. Collins (Eds,). Traumatic brain injury in sports (pp. 45-70). Lisse, The Netherlands: Swets & Zeitlinger.

Green, G.A., & Jordan, S.E. (1998). Are brain injuries a significant problem in soccer? Clinics in Sports Medicine, 17, 795-809.

Guskiewicz, K.M., Weaver, N.L., Padua, D.A., & Garrett, Jr., W.E. (2000). Epidemiology of concussion in collegiate and high school football players. The American Journal of Sports Medicine, 28, 643-650.

Hawley, C.A., Ward, A.B., Magnay, A.R., & Long, J. (2004). Outcomes following childhood head injury: A population study. Journal of Neurology, Neurosurgery and Psychiatry, 75, 737-742.

Hessen, E., Nestvold, K., & Anderson, V. (2007). Neuropsychological function 23 years after mild traumatic brain injury: A comparison of outcome after paediatric and adult head injuries. Brain Injury, 21, 963-979.

Iverson, G.L., Lovell, M.R., & Collins, M.W. (2003). Interpreting change on ImPACT following sport concussion. The Clinical Neuropsychologist, 17, 460-467.

Kirkwood, M.W., Yeates, K.O., Taylor, H.G., Randolph, C., McCrea, M., & Anderson, V.A. (2008). Management of pediatric mild traumatic brain injury: A neuropsychological review from injury through

recovery. The Clinical Neuropsychologist, 22, 769-800.
Langlois, J.A., Rutland-Brown, W., & Wald, M.M. (2006). The epidemiology and impact of traumatic brain injury: A brief review. Journal of Head Trauma Rehabilitation, 21, 375-378.
Lovell, M.R., Collins, M.W., Iverson, G.L., Field, M., Maroon, J.C., Cantu, R.,...Fu, F.H. (2003). Recovery from mild concussion in high school athletes. Journal of Neurosurgery, 98, 296-301.
Lovell, M.R., Collins, M.W., Iverson, G.L., Johnston, K.M., & Bradley, J.P. (2004). Grade 1 or "ding" concussions in high school athletes. The American Journal of Sports Medicine. 32, 47-54.
Lovell, M.R., Collins, M.W., Podell, K., Powell, J., & Maroon, J. (2000). Immediate Post-concussion Assessment and Cognitive Testing. Pittsburgh, PA: NeuroHealth Systems, LLC.McCrea, M., Hammeke, T., Olsen, G., Leo, P., & Guskiewicz, K. (2004). Unreported concussion in high school football players: Implications for prevention. Clinical Journal of Sport Medicine, 14, 13-17.
McCrea, M., Kelly, J.P., Christopher, R., Cisler, R., & Berger, L. (2002). Immediate neurocognitive effects of concussion. Neurosurgery, 50, 1032-1042.
McCrory, P.R., & Bercovic, S.F. (1998). Second impact syndrome. Neurology, 50, 677-683.
McKeever, C.K., & Schatz, P. (2003). Current issues in the identification, assessment, and management of concussions in sports-related injuries. Applied Neuropsychology, 10, 4-11.
McKinlay, A., Dalrymple-Alford, J.C., Horwood, L.J., & Fergusson D.M. (2002).Long term psychosocial outcomes after mild head injury in early childhood. Journal of Neurology, Neurosurgery and Psychiatry, 72, 281-288.
Moser, R.S., Schatz, P., & Jordan, B.D. (2005). Prolonged effects of concussion in high school athletes. Neurosurgery, 57, 300-306.
Pellman, E.J., Lovell, M.R., Viano, D.C., & Casson, I.R. (2006). Concussion in professional football: Recovery of NFL and high school athletes assessed by computerized neuropsychological testing. Neurosurgery, 58, 263-274.
Powell, J.W., & Barber-Foss, K.D. (1999). Traumatic brain injury in high school athletes. The Journal of the American Medical Association, 282, 958-963.
Satz, P. (2001). Mild head injury in children and adolescents. Current Directions in Psychological Science, 10 (3), 106-109.
Satz, P., Zaucha, K., McCleary, C., Light, T., Asarnow R., & Becker, D. (1997) Mild head injury in children and adolescents: A review of studies (1970-1995). Psychological Bulletin, 122, 107-131.
Schatz, P., Pardini, J.E., Lovell, M.R., Collins, M.W., & Podell, K. (2006). Sensitivity and specificity of the ImPACT Test Battery for concussion in athletes. Archives of Clinical Neuropsychology, 21, 91-99.
Schulz, M.R., Marshall, S.W., Mueller, F.O., Yang, J., Weaver, N.L., Kalsbeek, W.D.,...Bowling, J.M. (2004). Incidence and risk factors for concussion in high school athletes, North Carolina, 1996-1999. American Journal of Epidemiology, 160, 937-944.
Theye, F., & Mueller, K.A. (2004). "Heads up": Concussions in high school sports. Clinical Medicine and Research, 2, 165-171.
Thurman, D.J., Branche, C.M., & Sniezek, J.E. (1998). The epidemiology of sports-related traumatic brain injuries in the United States: Recent developments. Journal of Head Trauma Rehabilitation, 13, 11-8.
Tsushima, W.T., Oshiro, R., & Zimbra, D. (2008). Neuropsychological test performance of Hawaii high school athletes: ImPACT normative data. Hawaii Medical Journal, 67, 93-95.
Williamson, I.J.S., & Goodman, D. (2006). Converging evidence for the under-reporting of concussions in youth ice hockey. British Journal of Sports Medicine, 40, 128-132.Yeates, K.O., & Taylor, H.G. (2005). Neurobehavioural outcomes of mild head injury in children and adolescents. Pediatric Rehabilitation, 8 (1), 5-16

Table 1

Means and standard deviations of education and days post-injury for Concussion Groups

	No Concussion	Recent Concussion	Remote Concussion

	M	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*
Age	15.22	1.20	15.82	1.20	15.71	1.25	5.81	.003
Education	9.38	1.27	9.54	1.85	9.84	1.13	2.94	.054
Days post-injury			6.63	5.50	402.87	365.37	74.56	.000

Table 2

Means and standard deviations of ImPACT Composite Scores for Concussion Groups

	No Concussion		Recent Concussion		Remote Concussion				
	M	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*	*Partial eta²*
Verbal Memory	82.16	10.65	79.33	12.39	84.95	11.57	4.19	.016	.013
Visual Memory	70.80	13.22	69.44	15.18	71.26	14.72	2.76	.064	.009
Motor	35.83	7.30	34.75	8.39	34.85	8.56	2.45	.086	.008
Reaction Time	0.62	0.09	0.60	0.09	0.63	0.08	1.05	.352	.003

Table 3

Means and standard deviations of ImPACT Composite Scores for Age Groups

	12-13		14		15		16		17-18				
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*F*	*p*	*Partial eta²*
Verbal Memory	81.03	10.04	80.89	10.93	82.09	11.68	82.42	11.43	83.15	9.43	4.16	.002	.026
Visual Memory	69.29	12.31	69.26	13.76	68.85	13.79	72.35	13.45	73.67	12.57	5.58	.0001	.035
Motor	31.52	5.98	34.22	7.28	35.70	7.14	36.83	8.14	37.14	7.31	4.63	.001	.029
Reaction Time	0.67	0.12	0.64	0.09	0.62	0.10	0.61	0.08	0.60	0.07	2.21	.067	.014

Have Institutional Review Board Regulations Affected Research Approval Patterns?

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Abstract

Medical and comprehensive university Institutional Review Board for the Protection of Human Subjects research protocol approval rates and days to approval, before and after the implementation of governmentally imposed accountability, privacy, and protection regulations, were evaluated. We hypothesize