Title: Governmental risk management implications of mild traumatic brain injury (mTBI) in the Ute football program

Topic: Risk management in public education sports

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Abstract: Beginning in August 2010, the National Collegiate Athletic Association (NCAA) required all Football Bowl Division (FBS) participants, including the University of Utah "Ute" football program, to submit a concussion management plans (NCAA, 2010h, 55). Based on analysis of publicly available Ute end-of-season game participation reports for five seasons (2005-2006 to 2009-2010), 183 Ute players experienced 3,555 athletic exposures in 65 regular contest games (Table 1). (An athletic exposure is one player participating in one game.) The expected severe and mild traumatic brain injury (TBI) syndrome incidence rate in college football is 3.1 to 3.7 per 1,000 high school and college football athletic exposures (Table 2). Applying those incident rates to 183 University of Utah football players during those five seasons, the Ute team would have been expected to experience between 2 and 3 severe and mild traumatic brain injury (TBI) incidences per year or a total between 10 and 16 concussive events, but local public media reported no Ute concussive injuries during those five years. Individual Ute player exposure to contested matches during these five seasons were skewed towards a small core of starting (4%,n=8 of 183) and playing (23%, n=43 of 183) athletes (Table 1), but this result is expected and consistent with the starting team model of play used in modern collegiate football. Anecdotal review of footage of a Ute game indicates that Ute offensive and defensive players still use traditional "heads-down" "spearing" and "torpedoing" movements that can lead to mild traumatic brain injury syndrome (mTBI). The NCAA's new concussion management plan requirement provides an opportunity around which Utah college and high-school football coaches can rally to accelerate implementation of changes to practice drills and play techniques that will reduce the sports public health risk of mTBI.

Keywords: mild traumatic brain injury; collegiate sports; football; incidence; prevention.

Introduction

mTBI is a public health issue in college football sports. College football player mTBI can only be addressed through coaching that enforces NCAA Rule 9.1.2.1 (NCAA, 2008, see NATA, 2008) that requires play in a "heads-up" position. Better player protection through improved helmet design cannot solve the mTBI college football public health problem. Because mTBI in college football can only be mitigated by rule changes that lower game aggression, and hence the entertainment value of the game, the University of Utah concussion management plan has implications for the future of Utah's Football Bowl Subdivision (FBS) program and its pursuit of a Bowl Championship Series (BCS) trophy. By literature review, this paper explores other implications of how recent advances in medical knowledge about mild traumatic brain injury syndrome affects college football.

What is mTBI and how is it different from other types of brain injury?

Sport concussive injuries manifest in several grades of severity. Recently, the more severe but rare forms of sport concussive injury have been the subject of sensational media reports. Acute concussion and the severe brain trauma (involving intercranial bleeding and cerebral edema) are rarer forms of TBI. Repetitive concussions can lead to another rare manifestation - chronic traumatic encephalopathy (CTE) (see Talan, 2008). In two September 2010 House committee hearings (H.R. 1347, 2010; HR6172 Hearing, 2010), the mother of Owen Thomas, the former 21 year-old captain of the University of Pennsylvania football team, clutched her son's football helmet while testifying (CNN, 2010; FoxNews.com, 2010; Samson, 2010). She related how in April 2010, Owen committed suicide by hanging after becoming depressed. Although the cause of his behavior was initially unclear, a subsequent autopsy revealed CTE (CNN, 2010), presumably caused by unreported repetitive concussions during Owen's high-school and college athletic career. Repetitive head injury syndrome (RHIS), another severe chronic form of TBI, involves multiple repetitive impacts, for example, as seen in NFL professional players who in retirement develop memory loss from years of violent game play (Cifu et al., 2008, Guskiewicz et al., 2005, see Kain, 2009).

Second impact syndrome (SIS) involves a player suffering a second concussion during play before their first concussion has fully resolved (Cifu et al., 2008, "Background"). During the fall of 2005, 19 year-old La Salle University football player Preston Plevertes suffered a diagnosed concussion, but shortly thereafter, a La Salle team physician, a team athletic trainer and a La Salle student health care nurse all cleared Preston for return-to-play (Complaint, 2007; ATLA, 2010). A month later in a game with Duquesne University, an opposing player allegedly made an intentional and illegal hit on Preston's helmet. Preston stood up momentarily, collapsed into a coma, and now requires full-time medical care for the remainder of his life (Complaint, 2007; ATLA, 2010).

Mild traumatic brain injury syndrome is the more frequent form of concussion that involves temporary loss of consciousness, transient disorientation, dizziness, headache or any other neurocognitive change associated with an impact to the head (NCAA, 2010h, 53, Table 1, McCrory et al., 2009, 186). For example, in November 2010, former BYU Cougar and now NFL receiver Austin Collie was carried off the field after losing consciousness for several minutes as a consequence of being hit in the helmet during a professional football game (Wilner, 2010). Although I searched local media reports covering the 2004-2005 to 2009-2010 seasons, I found no articles concerning Ute football team members being removed from play for concussion. During the current 2010-2010 season, the Ute football program reported a number of player removals for mTBI. Moreover, team medical records are confidential and are not available for public review (FERPA, 2008; HIPPA, 1995).

But such events do occur as revealed by concussion injuries recently suffered on the Ute football team during the current 2010-2011 season. On November 15, 2010, the University of Utah Athletic Department removed Ute running back Sausan Shakerin from play for the remainder of the season after Shakerin suffered from several months of persistent headaches and nausea following pre-season practices (Hibbard, 2010; Statfox.com, 2010; Wodraska, 2010). On October 19, the athletic department removed Ute tight-end Brad Clifford from play indefinitely based on a concussive injury (Statfox.com, 2010). On November 13, the university athletic department also removed linebacker Jamel King from play for extended recovery after King reported disorientation symptoms (Statfox.com, 2010; Wodraska, 2010). Following a practice hit, King described how, "after a while, it felt like I was almost in a dream." (King qtd. in Wodraska, 2010).

Famous former Utah college football players also report suffering mTBI. In a November 2010 interview, former BYU quarterback Steve Young, who retired in 2000 after his fourth career concussion, described similar disorientation where after the game of his career ending concussion, he could not remember the throwing the winning touchdown pass (Simers, 2000). Young described his mental state after a concussive helmet hit, "It's like you are one-quarter there. . . . . I can remember and I can actually call plays, but the next play - but if you asked me what I just did, I would have no idea." (Young qtd. in Nickles, 2010, at 00:01:40). Recently, Ute coach Kyle Whittingham recalled that he suffered several headaches after being hit as a young college football player, and he speculated, jokingly but also perhaps with a partial sense of fact, that those mTBI-like events "[m]aybe [explain] that is why I am so loopy now." (Whittingham qtd. in Wodraska, 2010).

mTBI is the form of concussion that this paper is concerned with, and by qualification, the more severe forms of TBI like CTE, SIS, and RHIS, are excluded from the scope of this discussion.

This paper is based only on a literature review and publicly available documents on the University of Utah Athletic Department's website (Univ. of Utah Athletic Dept., 2010a). This paper was written without interview of the department.

Does mTBI in college football matter?

All issues worthy of public discussion are subject to the predicate question, "Why does it matter?" Why should we care that 10 to 16 Ute football players might have headaches over a five year period (or 2 or 3 per year), beyond the liability risk of extraordinarily rare and tragic catastrophic injuries such as that that Preston Plevertes will suffer for the remainder of his life?

First, mTBI and TBI matters because civil liability for the injury can lead to a university end its football program. In 2007, La Salle university terminated its football program in response to the SIS suffered by Preston Plevertes. La Salle is small catholic university with about one-half the student population of the University of Utah (Univ. of Utah OBIA, 2010; La Salle Univ., 2010b), and when Preston's disability guardians sued La Salle for training and medical negligence and to obtain funds to pay for his $800,000 in past medical expenses and $100,000 in future annual long-term care costs, the university ended its football program (La Salle Univ., 2007). La Salle was the largest participant in the small Metro Atlantic Athletic Conference that consists of 10 small northeastern colleges. The year after La Salle ended its football program, the entire Metro Atlantic conference ended conference football play. In December 2009, La Salle settled with Preston's guardians for $7.5 million dollars without admission of liability (ATLA, 2010; Docket, 2010; La Salle Univ., 2010a; Staar, 2010).

Second, NCAA universities, including the University of Utah, owe a duty to their players to minimize health injuries, and coaching decisions can change the rate of mTBI experienced a university's players. NCAA Const., Art. 2, §2.2 (Nov. 21, 2005) provides that, "Intercollegiate athletics programs shall be conducted in a manner designed to protect and enhance the physical and educational well-being of student-athletes . . .", and subsection 2.2.3 also provides that "It is the responsibility of each member institution to protect the health of and provide a safe environment for each of its participating student-athletes." (NCAA, 2010a, 3). The University of Utah contractually committed to these goals.

The University assigns the responsibility to comply with these health and safety rules to Athletic Department coaching and medical staff. While medical staff have primary control over supervising a TBI or mTBI injured player back to health, coaches often feel that they have the primary duty to manage an athlete's recovery, that coaching staff are better informed as to a player's health status and an athlete's capabilities than medical consultants, and that a coach's function is to "push athletes to the limits" within the bounds of reasonable risk (Schier et al., 2010, 334 *citing* and *quoting* Podlog and Eklund, 2007). One professional soccer coach interviewed by Podlog and Eklund (2007) illustrates this commonly held view, "We believe that [the athlete] has too much time where they do nothing and while theyre doing nothing, everything is degenerating. We believe they shouldnt [sci] do nothing, they should do something, even if its [sic] a little something." Podlog and Eklund, 2007, 213-214.

Substantial uncertainty surround mTBI syndrome, and because of this uncertainty, risk managers, athletic department staff and student players are presented with new and complex liability, return-to-play and retirement decisions. With current knowledge, coaching staff and medical professionals cannot reasonably foresee or mitigate mTBI except by making fundamental changes to college football play that will reduce the contest entertainment value of the game. This further increases the risk of liability that the University might incur by sponsoring football.

The answer to the question "Why does mTBI matter" also lies in the national scope of TBI in the general population and uncertainty as to the incidence rate of sports concussive injuries. While the five-year athletic exposures for the Ute football team totals 3,555, during an analogous five NCAA fall football seasons for 2004-2009 and including all NCAA football divisions, college football players had an estimated 2,153,835 athletic exposures in contested games and another 23,215,936 athletic exposures in practice games, or about 25,075,000 exposures per year (Marshall and Corlette, 2009, Table 3.1). Division I football game competitions had 884,380 athletic exposures over five seasons, or 176,876 per year (Marshall and Corlette, 2009, Table 3.1). In the national college football context of approximately 120 NCAA FBS teams, the Ute expected 2 or 3 TBIs per year becomes an expected national incidence in contest game of 548 to 654 per year. The NCAA Injury Surveillance System (Datlsys Center) estimated the number of concussions in college football games during the those five fall seasons at 1,496, with the reservation that their count includes adjustments for under-reporting error (Marshall and Corlette, 2009, Table 3.10).

And these actual national college football concussions that occurred between 2004 and 2009 are only a small part of a larger sport and non-sport concussive public health problem. In 2004-2005, about one-half of the nation's high-school students - over seven million - participated in athletic programs (Knowles et al., 2006, 1209), and in 1991, high-school athletes were first identified as the largest at-risk group for concussive injury of both the severe and mild type (Schulz et al., 2004, 937). In 2009, approximately 1,500,000 high-school students participated in school-sponsored football and about 75,000 students participated in college football programs (Mueller and Colgate, 2010, 6).

In 2003, the National Center for Disease Control (CDC) and the National Center for Injury Prevention and Control (NCIPC) estimated that in 1991, the national annual number of severe and mild TBI's totaled 1.5 million, and sports related concussions, including both the college football and high-school football exposures discussed above, were estimated at 20% of that total, or in 1991, about 306,000 severe and mild injuries (CDC & NCIPC, 2003, 9-10). Of those 1991 cases, only 12% of sports-related TBI injuries resulted in hospitalization and, by implication, 88% of TBIs do not require hospitalization. Thus, the CDC concluded that "most sports-related traumatic brain injuries fall into the mild or moderate category." (CDC & NCIPC, 2003, 10).

Thurman and Miller, 2001 estimated the cost of *only* mTBI hospitalizations (about 2.4% [20% times 12%] of all severe and mild TBIs) in 2001 totaled $16.7 billion (Thurman and Miller, 2001, Miller, 2001 qtd. in CDC & NCIPC, 2003, 11). But the CDC found that this updated estimate understates the true social cost of mTBI, since the estimate excludes "injured persons treated in other, non-hospital medical care settings, such as private physicians offices; the costs of lost productivity and lost quality of life; and indirect costs borne by family members and friends who care for persons with MTBI." (CDC & NCIPC, 2003, 11). In conclusion, public health researchers do not know have a good estimate for what the amount of the true economic loss of mTBI is generally or, specifically, what is the loss for sports-related mTBI in high-school or college athletes. But that economic loss is much greater than the known portion of the $16.7 billion estimated hospitalization loss in 2001.

In short, mTBI in college sports matters as public health, risk management and player equity issue.

What do clinicians and medical researchers know (and not know) about mTBI in college football?

Most injury and training characteristics related to mTBI in college football are known only with uncertainty, and coaching staff's common-sense intuition may unreasonably risk an mTBI athlete's recovery. Researchers do not know most basic mTBI characteristics with reasonably certainty, including the true injury rate, player under-reporting of injuries, the impact needed to induce a severe concussion or mTBI, the probability of short term recovery, the long-term cognitive effects of mTBI, how athletic staff and players interact to management recovery, and the efficacy of changing player tackling techniques, helmet technology and/or rule changes.

Clinicians and researchers imperfectly know the true incident rate for college football TBI incidents due to exposure skew and underreporting. Table 2 lists key retrospective and prospective cohort studies of TBI rates in college football. Because of the high left skew of athletic exposures (see Table 1), retrospective studies inaccurately estimate the true incident rate. For example, Dick et al. (2007)'s retrospective study in Table 2 states an incident rate (33 per 1,000 athletic exposures) that is ten times the rate from prospective cohort studies like Guskiewicz et al. (2003) and Knowles et al. (2006) (3.7 and 3.5 per 1,000 athletic exposures). Guskiewicz et al. (2003) used a prospective cohort study method to obtain a better estimate of the college football incident rate (3.7 per 1,000 athlete exposures) by randomly assigning players cohorts and then observing them over a period of time.

But Kevin Guskiewicz, and his co-researchers at the Department of Exercise and Sport at the University of North Carolina at Chapell Hill, notes that player-underreporting of TBI incidents significantly confounds estimates of incident rates from well-designed prospective cohort studies, "It is possible that some players who may have had a concussion during the study period were not identified. Researchers and clinicians have long thought that the rate of concussion is likely underestimated because of the reluctance of some athletes to report or their inability to recognize the signs and symptoms of concussion." (qtd. Guskiewicz et al., 2003, 2554, citation omitted, McCaffrey et al., 2007, 1242, McCrea et al., 2003, 2562, NCAA, 2010h, 52). But Schulz et al. 2004 concluded based on sensitivity analysis that underreporting even up to 20 percent would not effect the validity of TBI incident rates found their study (Schulz et al., 2004, 943).

College football players have several motivations for underreporting, for example, simple reclutance and lack of knowlege of the signficance of their symptoms (Guskiewicz et al., 2003, 2554). Quarterback Steve Young pointed to team loyalty: he did not want to interrupt play that would inconvenience his team mates or thousands of stadium fans from one individual's headache (Nickles, 2010). Ute running back Shakerin waited several months before reporting his persistent headaches, apparently from lack of understanding that persistent symptoms may indicate a severe TBI (Wodraska, 2010). Players may be pressured by coaches to play through recovery (Podlog and Eklund, 2007, 213-214), and football athletes view themselves as a part of "warrior culture" in which "playing with pain" is an expected player value (Staar, 2010, 52). William Staar, a defense attorney, suggests another factor not mentioned by clinical researchers: players fear losing their team position, if they report a concussion injury that might remove them from play for an extended recovery period (Staar, 2010, 52). Additionally, some college football players depend on their athletic scholarships to finance their college education, and they have no other economic alternatives. Some players have a substantial financial interest in not reporting their severe TBI or mTBI symptoms.

Clinicians and researchers do not know what structural damage or biochemical change that mTBI causes in the brain. mTBI is a syndrome - a set of signs that are associated with a pathologic condition. Because it is syndrome, mTBI may cause bio-mechanical injury to the brain by multiple unknown bio-chemical pathways (Stocchetti and Longhi, 2010). While structural changes in the brain can be imaged in the more severe forms of TBI (McArthur et al., 2004, Fig.s 3-9), the effects of mTBI cannot be seen as a structural abnormality on MRI or functional MRI (fMRI) scans (McCrory et al., 2009, 187). mTBI creates no consistent set of chemical blood markers, and researchers have been frustrated in attempts to create a blood test that would measure the presence and severity of injury to brain tissue (Pineda et al., 2004; Stocchetti and Longhi, 2010).

Although in November 2010, the U.S. Army announced Phase II clinical trials for a TBI blood test (Zoroya, 2010) and the NFL immediately expressed interest in using the new test on professional football players (Rosenthal, 2010), Dr. Jeffrey Barazin, a trauma specialist, recommends caution, since this new blood test was initially developed for hospitalized Iraq and Afghanistan veterans severely injured by improvised explosive devices (IDE). The new blood test may not be effective in detecting the less severe injury of mTBI syndrome in the general population. (Zoroya, 2010).

A consequence of the lack of direct serological tests that would directly confirm an injury is that researchers and clinicians can only measure the severity of and recovery from a mTBI by less accurate and indirect means, *i.e.* - neurocognitive testing. Clinicians use graded scoring cards to assess a player's mental responsiveness (McCrory et al., 2009, 185 and Appendix copy, SCAT2 field testing card, McCrea et al., 2003, Peterson et al., 2003). Manual graded neurocognitive tests have the drawback that players can memorize the card's short word list in order to avoid athletic trainers and medical staff detecting their concussion. Computerized neurocognitive testing overcomes this limitation by measuring an athlete's ability to recall a string or random words from a large bank of words that cannot be memorized or by measuring the athlete's fine motor skills by quickly moving a mouse cursor over a dot randomly displayed on a computer screen (e.g. Collins et al., 2006, Schatz et al., 2006). The NCAA requires minimum neurocognitive testing by any generally accepted test, including SCAT2, and only optionally suggests computerized testing (NCAA, 2010h, 56) on that grounds that the efficacy of computerized tests is unproven (NCAA, 2010h, 54). Makdissi et al. (2010), based on comparative testing of manual and computerized assessment of 1015 Australian soccer players found the opposite - computerized neurocognitive testing is superior in monitoring mTBI symptoms in recovering athletes (Makdissi et al., 2010, 769, Fig. 1).

Clinicians and researchers have no clear understanding of what impact force will induce an mTBI in college football. Using innovative helmet telemetry systems, researchers at Brown, Dartmouth, the University of North Carolina, and Virgina Tech, measured real time g-forces experienced by small samples of NCAA Division I college football athletes (typically less than 75 players) during practice games (Brolinson et al., 2006; Crisco et al., 2010; Guskiewicz et al., 2007;

Mihalik et al., 2007; Rowson et al., 2009). Guskiewicz et al. (2007) recorded that college football helmet impacts resulted in accelerative/decelerative g-forces on a player's head with a mean of 102.8g (60g-169g), but they found no clear relationship between those g-forces and 13 players who suffered concussive injuries (Guskiewicz et al., 2007, 1247). McCaffrey et al. (2007) found no mTBI's in college football athletes exposed to up to 90g forces, and could detect no defined threshold force above which a mTBI would be induced and below which a TBI would not occur (McCaffrey et al., 2007). Conversely, Mihalik et al. (2007) found that NCAA football players suffered TBI injuries in practice games at g-forces between only 21g to 23g, concluding that, "[T]here seem[s] to be no 'light' days for football players." (Mihalik et al., 2007, 1229). Mihalik et al. (2007)'s findings imply that clinicians and coaching staff have no reliable method to identify and direct players, who may be particularly susceptible to mTBI, to other less risky sports.

Researchers know that mTBI effects are cumulative. Schulz et al. (2004) found that high-school football players who have experienced one concussion have a two-fold increased risk of incurring a second concussion. Guskiewicz et al. (2003, 2552) found a three-fold increase in risk and an associated increase in the time to full-recovery (Guskiewicz et al., 2003, 2552-2553, Table 4). Thus, Guskiewicz et al. (2003, 2553) recommends that, "[A]thletes with a high cumulative history should be more informed about the increased risk of repeat concussions when continuing to play contact sports such as football." (Guskiewicz et al., 2003, 2553). These findings also imply that concussion may cause a permanent change to the brain's micro-structure or to brain chemistry that predisposes a football player injured by the first impact to suffer an injury on a second impact, but Schulz et al. (2004) noted that an alternative explanation is the player exposure skew effect, illustrated for the Ute team in Table 1 (Schulz et al., 2004, 942-943).

Clinicians and researchers do not know if mTBI in college football is linearly or exponentially dose dependent (Schulz et al., 2004, 942-943, cf. Guskiewicz et al., 2003, 2553-2554). In this context, dose dependency means that if a football player is exposed for a set duration of game contested play and their risk of incurring a mTBI is *P*, then if that player is exposed to twice that duration of play, then the player's risk of mTBI is *2P*. If mTBI is exponentially dose dependent, then a player's risk of incurring a mTBI increases rapidly the more they play - a key concern for starting football college players who have the greatest number of athletic exposures (Table 1). Guskiewicz et al. (2003, 2554) was able to pair only limited player athletic exposure data with player concussions in a small group of 120 players.

Clinicians and researchers know that full recovery for a mTBI player takes a few days to three months (Guskiewicz et al., 2003, 2552-2553, Table 4, McCrea et al., 2003), but lacking a biomarker blood test, clinicians can only monitor a player's progress to full-recovery by less accurate and indirect neurocognitive testing. McCrea et al. 2003 found in a sample of 79 college football players from 15 U.S. universities who suffered concussion that 84% recovered within 3 months - the length of the fall regular season NCAA play. Significantly, McCrea et al. 2003's finding imply that 16% *do not recover* during that period.

Researchers have a limited understanding of coach-player-clinician interaction during the return-to-play or retirement-from-play decision making process. This critical return-to-play and retirement-from-play process has not been extensively studied (Schier et al., 2010, 333). Podlog and Eklund (2007) examined coaches views on injury, discussed above. Creighton et al. (2010) outlines a 3-step return-to-play decisionmaking system in which the roles of the player, coach and medical clinician are explicitly stated.

Clinicians and researchers only partially understand the long-term adverse effects of mTBI. mTBI neurocognitive changes are permanent but subtle, particularly for athletes who experienced multiple concussions. When validating a preseason TBI baseline assessment checklist, Register-Mihalik et al. (2009) found a statistically significant association between high-school and college-football player reports of headache, difficulty concentrating and irritability and athletes who had suffered and recovered from multiple concussions (Register-Mihalik et al., 2009). Guskiewicz et al. (2003) interviewed 2,552 retired NFL players, 61% of whom experienced one concussion and 24% of whom suffered three or more concussions. Guskiewicz et al. (2003) found in those retired players a statistically significant association between mild cognitive impairment (MCI) and experiencing a concussion (Guskiewicz et al., 2003). An older individual with MCI has reduced cognitive abilities relative to the norm, but they do not exhibit symptoms sufficiently severe to be diagnosed as having dementia (Guskiewicz et al., 2003, 720). Furthermore, the association was non-linear: players who suffered three or more concussions had five times the rate of being diagnosed with mild cognitive impairment as players who had no concussion (Guskiewicz et al., 2003, 722). In a small sample of 50 former Canadian hockey and soccer athletes who had not played in over 30 thirty years, De Beaumont et al. (2009) found through neurocognitive testing, such as rapid movement testing, that former athletes with concussions had statistically significant lower response rates than athletes who had no history of concussion (De Beaumont et al., 2009, 703). But, the athletes that De Beaumont et al. (2009) studied showed no gross deficits; the athletes' neurocognitive deficits were in subtle reductions to their motor skills.

Clinicians have no effective drug treatments that specifically target mTBI. "Off-label" drug therapies are available to clinicians (Cifu et al., 2008), but McCrory et al. (2009) recommends limiting drug therapy to managing acute cases with extreme symptoms (McCrory et al., 2009, 189). Drug therapy has limited application to mTBI because the underlying biochemical basis of the injury is unknown. As McCrory et al. (2009) notes drug therapies may mask the mTBI symptoms of injured athletes, and clinicians may incorrectly conclude that an injured player has fully recovered based on false positive results from follow-up neurocognitive testing. The injured player, incorrectly believing that they are fully recovered, might return-to-play early, but actually be at risk to suffer a life-threatening SIS injury - as occurred to Preston Plevertes. In short, the only currently available medical treatment for mTBI is for clinicians to monitor the progress of the body's natural healing process in order to assure that a player does not return-to-play early.

An alternative to creating mTBI post-injury treatment is to prevent the injury from occuring. Industry, primarily through helmet manufacturers such as Riddell Corporation, have developed improved helmet designs. Collins et al. (2006) validated Riddell's claims that its designs do significantly reduce the risk concussion (31%) (Collins et al., 2006, Blackman et al., 2007, 18-20), but the Collins study has been criticized for methodology errors and on the grounds that Riddell sponsored the research (Staar, 2010, 54-55). *See* Staar, 2010, 54-55 for a description of other major helmet designs and manufacturers. Xenith Corporation's X-1 model lines the helmet with air cushion pads (Blackman et al., 2007, 20, Staar, 2010, 54). Recreational runners who have used Nike "Air" running shoes will be familiar with the air-cushion pad design concept.

But sports injury researchers have pointed out that athletes compensate for improved protective gear; elite athletes play to a level-of-injury necessary to achieve their competitive goals. Frederick Mueller of the National Center for Catastrophic Sports Injury Research, a centered funded in part by the NCAA, has tracked significant injuries in high-school and college sports for over 30 years for the purposes of identifying the causes of disability and death and for the purpose of proposing responses to reduce that such injuries (Schwarz, 2010a, Mueller and Cantu, 2010). Mueller and Cantu (2010b, 5) tabulated less than 10 total high-school and college football permanent, unresolved cervical spinal cord injuries in players per year from 1991 to 1998, but they tabulated more than 10 such unresolved injuries in four of the seven years between 2001-2008. Based on other NCAA statistics, Guskiewicz found that the rate of TBI injuries in college football is increasing. Between 2000 to 2005, concussions in NCAA football increased from 2.91 to 3.91 per 1,000 athletic exposures (Guskiewicz et al., 2007, 1243-1244). The conclusion drawn from these findings is that during a period in which football protection technology was improving, head injury rates nonetheless increased. Players are sensing the improved protection and compensate but hitting harder in order to achieve their competitive goals. Thus, increasing football padding or improving helmet design may only temporarily, but not permanently, reduce player risk for mTBI.

Because of this inherent risk of head injury, Mueller and Cantu (2010b) make the following recommendations to college football coaches:

> 1\. . . . Because head contact largely caused these injuries it is important to remember the lesson to keep the head and face out of blocking and tackling. Coaches should drill the players in the proper execution of the fundamentals of football - particularly blocking and tackling. *SHOULDER BLOCK AND TACKLE WITH THE HEAD UP - KEEP THE HEAD OUT OF FOOTBALL.*
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> . . . .
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> 4\. Coaches and officials should discourage the players from using their heads as battering rams when blocking, tackling, and ball carrying. The rules prohibiting spearing should be enforced in practice and games. The players should be taught to respect the helmet as a protective device and that the helmet should not be used as a weapon. *Ball carriers should also be taught not to lower their heads when making contact with the tackler.* (Mueller and Cantu, 2010b, 8-9) (Emphasis in original).

Mueller and Colgate (2010) also re-enforce that coaches are the central intervention by which TBI injuries can be reduced:

> Coaches who are teaching helmet or face to the numbers tackling and blocking are not only breaking the football rules, but are placing their players at risk for permanent paralysis or death. This type of tackling and blocking technique was the direct cause of 36 football fatalities and 30 permanent paralysis injuries in 1968. In addition, if a catastrophic football injury case goes to a court of law, there is no defense for using this type of tackling or blocking technique. (Mueller and Colgate, 2010, 5) (Emphasis in original omitted).

In summary, what researchers and clinicians know, and do not know, about mTBI is the following: a single mTBI concussion makes a permanent, but subtle change in the brain's structure and/or chemistry, the nature of which is unknown. There is no pharmacological treatment for the injury, but a player's recovery can be monitored using computerized neurocognitive testing in order to protect an elite athlete from the risk of a subsequent life-threatening SIS injury. Most players recover within one-week to three months, but players who elect to continue to play college football, which has a high incidence rate for concussion, risk suffering cumulative injury involving progressively longer recovery times. By continuing to play after their first concussion, college football players expose themselves to increased neurocognitive decline in old-age, the nature and extent of which is not fully understood at this time. Improved helmet technology may in the short term reduce the rate of college football concussions, but helmet technology holds little promise in mitigating mTBI risk because players will compensate for the improved technology by hitting harder. Researchers have concluded that they only way to reduce mTBI in college football is to change the way the game is played, *i.e.* - players must stay in a "heads up" position including when they are tackling and being tackled by other players. College football coaches, by changing their teaching of tackling techniques and through practice drills, are central to reducing the rate of mTBI. Improved helmet designs and post-injury medical treatment cannot mitigate college football's mTBI health risk; good coaching is the only currently viable solution.

How has the NCAA and the University of Utah responded to mTBI?

Because the risk and prognosis of mTBI in high-school and college football is uncertain and their are social benefits to the game, the *Consensus Statement on Concussion in Sport 3rd of the International Conference on Concussion in Sport* did not call for the end of United States football or of soccer internationally. Rather the *Consensus Statement* recommended that, "The competitive/aggressive nature of sport which makes it fun to play and watch should not be discouraged. However, sporting organizations should be encouraged to address violence that may increase concussion risk." (McCrory et al., 2009, 191).

Working in conjunction with medical and sports researchers Dr. Robert C. Cantu of the Neurological Sports Injury Center and Kevin M. Guskiewicz of the Departments of Sports Exercise Science and Orthopedics of the University of North Carolina at Chapel Hill, the sports organization with primary control over college football, the NCAA, has aggressively moved to conduct research, to implement rule changes, and to distribute educational materials designed to reduce the incidence of TBI and unnecessary violence in college football (NCAA, 2009, Copeland, 2010). The NCAA has implemented rule changes against helmet hits NCAA, 2008. The NCAA has distributed extensive educational materials to both coaches and players on the need to reduce concussive injuries through the reduction of helmet hits and on the need to report and treat injuries early (Coaches: NCAA, 2010c, NCAA, 2010d, NCAA, 2010f, Players: NCAA, 2008, NCAA, 2010b, NCAA, 2010e, NCAA, 2010g). In August 2010, the NCAA required all NCAA college football programs to adopt a written concussion management plan and adopted new guidelines for concussion management (NCAA, 2010h, 55). One key provision of the NCAA guideline is adoption of the best practice that places a concussion return-to-play decision solely under the medical staff and not athletic staff (NCAA, 2010h, 56). Through the NCAA, three universities have provided sample plans for use as drafting templates (Princeton University Athletic Medicine Dept., 2010, Univ. of GA, 2010, Univ. of N.C., 2010a). Consistent with NCAA guidelines, these plans require athletes to sign informal consent statements acknowledging that they understand the risk of TBI and that they must fully disclose any past or future concussive incident (*e.g.* - Univ. of N.C., 2010a).

The primary effect of these NCAA actions is to reduce the risk of life-threatening SIS and CTE by identifying at risk players early and by assuring that they return-to-play only after they fully recover (NCAA, 2010h, 52-56). Under the NCAA guidance, players must be removed from play for 24 hours immediately on suffering any concussion related symptom during a game such as headache, disorientation or dizziness. Players are then entered into a graduated, clinically supervised return-to-play monitoring program as suggested by medical research. As suggested by medical researchers, all players are given pre-season baseline examinations for later use in the event that they are injured.

The NCAA concussion management guideline partially implements the recommendations of Mueller and Cantu (2010b) and Mueller and Colgate (2010) by suggesting a best practice that "[A]thletics staff, student-athletes and officials should continue to emphasize that purposeful or flagrant head or neck contact in any sport should not be permitted and current rules of play should be strictly enforced." (NCAA, 2010h, 56).

A recent newspaper article regarding Ute running back Shakerin's retirement-from-play suggests that the Ute program is implementing most of these NCAA recommendations (Wodraska, 2010). As stated above, the University of Utah Athletic Department was not interviewed as part of the preparation of this paper.

What other enhancements could the University of Utah include in its concussion management plan?

But the NCAA concussion guideline only mentions pre-injury prevention (as opposed to post-injury treatment) in passing, and none of the NCAA's sample concussion management plans discuss preventing mTBI injury before injury occurs by changing how the game is physically played.

Based on increasing awareness of TBI and mTBI, other stakeholders on the fringe of the college and professional football world have begun to call for a fundamental change in play (Lipsyte, 2010, Matheson et al., 2010, Schwarz, 2010b). Lipsyte (2010), a sportswriter, mentions options to ban the three-point stance and bringing back "wrap-around" tackling. Matheson et al. (2010), a sports clinician, recommends that the medical community conduct an "intervention" in football by conducting an research program on the efficacy of various rule changes in reducing TBI and other injuries. Schwarz (2010b), a sports journalist, noted that "As discussion about the effects of brain trauma in football turns to avoiding it in the first place, ideas for reducing hits to the head include eliminating the three-point stance for linemen and strengthening rules regarding headfirst tackles."

The NCAA's requirement for a football concussion management plan provides an opportunity for NCAA member colleges and universities to build a consensus on implementing necessary fundamental changes in how the game is played as suggested by Cantu, Colgate, Mueller and the NCAA. In the era of million dollar BCS competition payouts, and multi-million dollar college football coaching contracts, any single university or college member of the NCAA FBS has a significant economic disincentive to not be the first team to adopt changes in play that will reduce player aggression and, by implication, a team's competitiveness. (The controversy surrounding how the BCS revenue stream has changed NCAA college football is beyond the scope of this paper. *See* Knight Commission (2010) for further background.)

Conversely, NCAA member colleges also have significant managerial interests in moving in a coordinated fashion toward reduced aggression play. Student players also have an increased awareness of mTBI and of the possibility that opposing players can be removed from a game for a single mTBI incident. A darker side of college and professional football is the players will occasionally have lapses in moral judgment and will make unsportsmanlike hits for the purpose of tactically removing a talented opposing player. A potential dark side of mTBI is that players, in such moments of poor judgment, paradoxically may increase the rate of mTBI through tactical removals of opposing players. If all NCAA FBS athletic programs move in concert and unambiguously in changing the nature of game play, then a clear message will be sent to players that tactical mTBI hits are not only unethical, they also are not in any individual player's best interest.

In its concussion management plan, the University of Utah could include objective targets for offensive and defensive practice drills that implement the NCAA "heads up" play rule, while still preserving team's competitiveness. The plan could include a requirement that team videos of each game will be evaluated by athletic staff and that each player will be scored with respect to compliance with the NCAA "heads up" play rule. Players accumulating a set number of points would be removed from starting play, temporarily suspended, or retired from the team.

None of the sample NCAA concussion management plans address the player disability compensation issue raised by McCrory et al., 2009, 191 or other player retirement fairness issues. NCAA ByLaw 16.11.1.4, amended Jan. 16, 2010 (NCAA, 2010a) now allows compensation to players to cover disability insurance. The University of Utah should explore providing disability insurance compensation. mTBI also presents a player fairness issue for football students that are forced to retire from play based on mTBI incidents. College football players invest a significant portion of their youth in qualifying for a college team, and for some, they have no other economic means to finance their college educations. Because of the uncertainty regarding the threshold force required to induce mTBI, the University of Utah should adopt a policy that formalizes the transfer of mTBI college football players to other sports that have a lower risk of concussive injury, while still continuing their sports scholarships.

Finally, the University of Utah football program by its position in the Utah amateur football community also sets the standard of play for Utah high-school football programs. The degree to which Ute football players continue to use a “spearing” and “torpedo” tactics has a trickle down effect to many of the University’s feeder high-schools.

The current NCAA “heads-up” play rule was adopted in 2008. Has the NCAA’s policy change been transmitted to college football players? The playing rules of the National Federation of State High School Associations also prohibit helmet-to-helmet contact and using the helmet as the primary point of contact, regardless of whether contact is made intentionally or unintentionally (Mueller and Colgate, 2010, 3-4). Anecdotally, footage of the recent local rivalry game in Utah - the annual Utah vs. BYU football game - was reviewed. Additionally, footage of local Utah high-school football games, that are broadcast on local television station Channel 19, were watched. Formal tabulations of helmet-to-helmet hits were not made, but even a cursory review of game videos revealed routine potentially mTBI inducing helmet hits that were not consistent with the NCAA’s “heads up” play directive. Based on this unscientific survey, the NCAA directive appears not to be rigorously followed in Utah college or high-school football play.

Conclusion

Having to change how football is played to increase player safety is not a new issue for the NCAA. The predecessor to today’s NCAA, the Intercollegiate Athletic Association of the United States, was formed in the 1905 in response to public disgust over the high number of player deaths in college football (NCAA, 2010i). In 1976 and in response to the high rate of permanent cervical spine injuries in high-school and college football players observed between 1971 to 1975, the

NCAA first adopted rules prohibiting player use of the helmet as the initial point of contact with an opponent (Mueller and Colgate, 2010, 3). Aggressive enforcement of that rule reduced permanent cervical spine injuries in high-school and college football players from 25 per year in 1975 to 2 per year in 1994 (Mueller and Colgate, 2010, 3,7). Unfortunately, like the increasing trend in TBI and mTBI injuries found by Guskiewicz et al. (2007, 1243-1244) between 2000 to 2005, permanent cervical spine injuries in high-school and college football players have returned to their historical levels of the 1970s (Mueller and Colgate, 2010, 7).

In conclusion, mTBI, like its sibling of permanent injury to the cervical spine, principally is a coaching management issue. Football does not need to be "saved from itself" as some have suggested in response to the increasing awareness of mTBI.

Utah college and high-school coaches have an opportunity to develop a game that is exciting and challenging for players and that has good entertainment value for spectators, but that has significantly reduced potential mTBI collisions. NCAA college athletic departments should use their control of a team's playing style to reduce the production of mTBI players that may suffer reduced concentration and mental agility needed to successfully complete their college careers and who may, years later as senior citizens, may suffer mild cognitive deficits. Such behavioral changes to football players' conduct can be achieved with significantly reducing the entertainment value of college football.

The only remaining meritorious controversy surrounding mTBI in football is the speed with which aggression-reducing styles of play are implemented. Utah college and high-school coaches can implement them slowly, or in response to civil litigation, they can implement them quickly. Plaintiff attorneys are well-schooled in the effects of slow-speed shaken-brain syndrome, because that type of injury is now a routine part of automobile personal injury claims. It is only a question of when, not if, the plaintiffs' bar will transfer their existing knowledge of brain injuries to the mTBI health issue in high-school and college sports.

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Appendix

Tables

Table 1

Utah college football player (N=183) contested game athletic exposures (N=3,555) during 2005-2006 to 2009-2010 regular season play

Exposures	Playing (%)	Starting (%)			
≤10	52 (28)	135 (74)			
11 to 20	52 (28)	23 (13)			
21 to 30	36 (20)	17 (9)			
13 to 40	29 (16)	8 (4)			
≥41	14 (8)	0 (0)			
Total	183 (100)	183 (100)			
Five-number summary					
Type	**Min**	**1st Qtr**	**Median**	**3rd Qtr**	**Max**
Starting	0	0	1	12	49
Playing	1	9	15	29	49

Notes: Numbers in parenthesis are percent. Exposures=Athletic exposures in stated range; Playing=number of athletes who played in a game in this exposure range; Starting=number of athletes in the starting line-up who played in a game in this exposure range. In five seasons between 2005-2006 and 2009-2010, 183 unique athletes experienced 3,555 contest athletic game exposures in 65 regular season games and excluding 1 post-season game. Tabulated from Univ. of Utah Athletic Dept. (2006), Univ. of Utah Athletic Dept. (2007), Univ. of Utah Athletic Dept. (2008), Univ. of Utah Athletic Dept. (2009), Univ. of Utah Athletic Dept. (2010a). The author's spreadsheet containing the raw tabulation Ute athletic exposures is available on request.

Table 2
TBI incidence rates for high-school and college football

Study	Type	Description	Rate[a]	95% CI	Rate Type
Dick et al., 2007, 2240, Table 1	Retrospective	16 years of NCAA Injury Survelliance Reporting System Data, including 7369 regular season games and 36,800 practice games	37.79	37.17-38.40	Contested games in Div. I
			2.02	1.97-2.06	Practice games in Div. I
Guskiewicz et al., 2003, 2551	Prospective cohort	2905 college football athletes in Div.s I, II & III	3.7	2.82-4.59	Contested games in Div. I
			0.39	0.29-0.49	Practice games in Div. I
Knowles et al., 2006	Prospective cohort	3,323 North Carolina high-school varsity football students 1996-1999	3.54	2.87-4.37	Practice & contested games
Marshall and Corlette, 2009, Tables 3.1 & 3.2	Retrospective	NCAA DatalysCenter injury and participation reports covering 16,277 concussions in 25,369,771 athletic exposures in Div. I,, II and III fall football seasons 2004-05 to 2008-09, adjusted for underreporting	2.91[b]	n/a	Contest games all Div.s
			0.41[b]	n/a	Practice games all Div.s
NCAA, 2010h, p. 52	Statement	n/a. (See Guskiewicz et al., 2007, 1243-1244).	3.1	n/a	Practice & Contested games in college football
Schulz et al., 2004, 940	Prospective cohort	19,903 North Carolina high-school athletes in 12 sports 1996-1999, including football	0.33	0.25-0.41	Contested games
			0.08	0.04-0.13	Practice games

Notes: a-Rate per 1,000 athletic exposures. b-Rate is computed in this paper from data reported by Marshall and Corlette, 2009, Tables 3.1 & 3.2.