Subconcussive Head Impacts in Soccer and a Method for Significantly Absorbing, Reducing and Dissipating Those Forces

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Abstract

Subconcussive impacts to the head, which do not meet the threshold level of a concussive force, have become a hidden epidemic in the world of contact sports, including soccer. Soccer players at all levels are subjected to these types of impacts every time they head a soccer ball. Subconcussive impacts are of increased concern to young athletes whose brains are not fully developed and who may be susceptible to enhanced brain injuries. Recent studies have shown that subconcussive insults not only lower the threshold for concussions, but can in and of themselves cause long-term brain trauma. Notwithstanding these studies, many questions remain unanswered and more research is needed to determine the short- and long-term effects of repeated subconcussive impacts. The ForceField FF Protective Sweatband, which combines the characteristics of an ordinary headband with the technology of protective helmets, reduces the severity of impact forces to the head and brain up to 80% for children and over 50% for adults. The ForceField FF Protective Sweatband is an intervening and proactive method for reducing the effects of the severity of impacts to the brain and\ will protect athletes of all ages from the lasting impacts of engaging in contact sports.

Keywords: subconcussive brain injuries-headgear protection in soccer-asymptomatic brain injuries

A. **Introduction**

Subconcussive head impacts are not hard enough to cause a concussion but are sufficient to jolt the brain and cause observable brain changes and damage. Heading the ball in soccer qualifies as a subconcussive contact, especially for young children whose brains are still in the earlier stages of development.

Over the last thirty years, I have been a member of several organizations involved in testing headgear and creating safety standards to protect athletes participating in contact and collision sports from subdural hematomas and possible concussions. Although it was generally known that concussions continually occurred in all of these sports, there were never any considerations as to the implications and long-term effects of subconcussive head injuries.

In 2000, I designed, developed and tested a new type of protective headgear which was initially created for the purpose of significantly reducing the impact forces to young children and teenagers resulting from heading a soccer ball. This novel approach was to combine the characteristics of an ordinary headband with the technology of protective helmets and create a protective sweatband. This protective sweatband is able to significantly reduce, absorb and dissipate the impact forces associated with heading a soccer ball (amongst other activities) and was awarded the CE II Mark designating the product as protective headgear following extensive independent testing.

The ForceField FFTM Protective Sweatband was the first protective headgear designed for soccer and other sports for the purpose of reducing the severity of impact forces to the brain without making any claims that it would minimize or eliminate concussions. It was the first time that headgear has been designed to significantly reduce the effective force of subconcussive impacts to the brain *and* meet all of the design requirements specified by the Fédération Internationale de Football Association (FIFA).

In 2001, I asserted that impact forces of heading the ball in soccer could cause significant damage to a child's brain. The rationale and reasoning behind this assertion was based on early European investigative publications, which found that soccer players who were known to head the ball were subsequently diagnosed with neurological deficits at an early age and subsequent autopsies confirmed a finding of chronic traumatic encephalopathy (CTE) in these players. After reviewing these publications from a technical standpoint, I deduced that these players' brain injuries could not have been the result of only concussive impacts, but instead, that subconcussive impacts played a significant role in causing these injuries (Abraham, 2001).

As late as 2011, and despite evidence to the contrary, a few medical specialists treating concussions rejected claims that subconcussive impacts could cause permanent brain injuries to children; indeed, these specialists went so far as to state that children playing soccer and other contact sports could safely withstand over 1,000 hits per season without head protection.

B. **<u>Recent Studies</u>**

There are many football, soccer and rugby players at all levels of their respective sports who have suffered permanent brain injuries. Those individuals who played professionally may have enjoyed the glory and monetary rewards during their careers, but a large number of them have also lost a quality of life that has affected their mobility and their ability to remember, speak and think. Some of these individuals are unable to work following their professional athletic careers and sometimes are so debilitated by migraine headaches that they cannot participate in normal everyday activities.

The public has witnessed many former sports heroes in wheelchairs or using walkers and canes with their lives in shambles. These athletes take a number of medications each day to ease their headaches, calm their erratic moods, aid their sleeplessness and help with their depression. In some cases, these medications may not be enough: a number of former professionals in football and soccer have gone so far as to commit suicide, many finding this as the easiest way out.

Former athletes who have suffered concussions and permanent brain damage have donated their brains to the Sports Legacy Institute (SLI) and other medical researchers so they can be studied for brain disease. Can these studies help the medical and scientific communities better understand when the brain diseases commenced, the level of impact or impacts that led to these diseases, the mechanism of the impact(s), what part of the brain the diseases originated from, the rate of the progression? I am not aware of one peer review article that answers any of the above questions within a *reasonable degree* of scientific or medical certainty.

SLI is studying both long-term effects of concussions and the damage which can be caused by multiple subconcussive hits. SLI now believes that *repetitive* subconcussive hits, like concussive impacts, can lead to CTE. The term "repetitive" is subjective and the amount varies with the level of subconcussive impact forces; the age, genetics and the neck and shoulder muscles of the individuals receiving those impacts; and the developmental level of the individual's brain. With those variables in mind, it would appear from a scientific standpoint that researchers will be initially satisfied with qualitative interpretations rather than quantitative. (2010)

Not one study involving the donated brains could determine whether subconcussive impacts contributed to the disease at any time prior to or during its progression. In fact, none of the investigators could ascertain whether subconcussive or concussive impacts caused, or how much each type of impact contributed to, the progressive brain disease. In "Your Body is Nothing Without a Brain," an article which I authored and which was published in the Spring 2011 issue of *Forensic Examiner*, I examined the subconcussive effects caused by heading a soccer ball and I asserted that subconcussive head injuries can be detrimental to young children. I also opined that subconcussive head injuries to young children may also have long-term effects that can manifest themselves 20 to 30 years later and which are similar to those injuries suffered by adults in collision sports. Recent scientific and medical research has supported my opinion relating to cumulative subconcussive impacts.

Scientists agree that infants and preschoolers up to the age of seven have a substantially higher vulnerability to neurological trauma than adults. Some of the long-term effects of trauma do not manifest themselves until the child has reached adulthood (Jeanette, 2001). Dr. Cynthia L. Beaulieu's findings show that children who sustained head and brain injuries in the first five to six years of their lives exhibited less recovery of and greater impairment to intellectual skills as compared with children who were between six and 16 years old. Dr. Beaulieu reported that the age at which the injury was received and its severity dictate the rate and extent of recovery from deficits in language, memory, attention and academic and decision-making skills (Beaulieu, 2002).

In a study of college football players at three Division I universities, Dr. Thomas McAllister, director of neuropsychiatry at the Dartmouth Hitchcock Medical Center, initially found that there were no significant lapses in cognition that might be considered a precursor to CTE. When the data was reexamined, it was found that 22% of those college players performed worse than expected on tests of verbal learning compared with only about 4% of athletes who engage in non-contact sports (McAllister, 2012).

The individuals in these studies were young adults. What these studies failed to address is: (a) whether a young child, whose brain and neck and back muscles are not fully developed, would suffer the same long-term effects as young adults; (b) whether there is a threshold for aging of the brain; (c) whether the number of hits or, more realistically, how hard the hits are, will be the catalyst for cumulative effects that will manifest itself in neurological deficits in the near future (or years from the initial impact); (d) how the actual number of hits can be a determining factor; and (e) does one need concussive in addition to subconcussive head impacts that will cause pathological events to accelerate the decline of cognitive function associated the with the aging of the brain.

Studies have established that if one part of the brain is damaged, other parts may learn to subtly duplicate the activity of that injured section. When this does occur, subtle differences cannot be measured by, for example, a simple impact test. As such, when young and older children receive subconcussive injuries, the impact may actually be greater if the uninjured portion of the brain imitates the portions that have been subjected to subconcussive impacts.

While these studies are informative, they do raise compelling questions that must be examined before we can have a full understanding of the potential injuries that children can sustain from subconcussive impacts:

- Does the damaged part of the brain progressively deteriorate?
- How can the subtle differences be measured?
- What is the rate of deterioration of a child's brain versus an adult's brain?
- How do stress variables, such as continual sports activities, television, school, and homework, affect the restitution of the brain?
- Does the child's brain ever return to normal following injury?
- Instead of becoming a neurosurgeon will the child become a lawyer? Will the same person become a postal worker instead of a teacher?

No one has any answers to these questions at the present state of medical research.

At present, it is not known whether asymptomatic subconcussive hits to the head trigger progressive degeneration of the brain tissue of children whose brain is not fully developed or at what level of trauma does progressive degeneration of the brain tissue, including the build-up of an abnormal protein tau. It is known in adults that these changes in the brain can begin months, years, and even decades after the last brain trauma. However, it is unknown whether a number of asymptomatic subconcussive hits to the head will manifest itself years after the traumatic insults resulting in various levels of progressive CTE. Moreover, we cannot presently ascertain at what level of impact force do the subconcussive hits change the asymptomatic symptoms and start exhibiting progressive degeneration. All of these questions have yet to be answered, but this does not undercut the importance of the answers to these questions if the medical profession is to fully understand the relationship of impacts to the brain.

In Australia, a study that was commissioned by the AFL Player's Association found that of nearly 600 former players surveyed, more than half had at least one concussion and more than a quarter had suffered three or more concussions. Critically, the study suggested that multiple hits to the head, not severe enough to cause concussions (known as subconcussive hits), may also lead to CTE.

In another study reported in the *American Journal of Sports Medicine*, Dr. Tracy Covassin reported that female and younger athletes take longer to recover from concussions than others (Covassin, 2012). The implications of these findings are extremely important and could change the nature of high-impact sports from professional athletes all the way down to young players, regardless of how administrators or spectators might feel.

What researchers found with CTE, which is defined by progressive neurodegeneration, is that the longer one survives with the disease, the worse it is going to get. It is a relatively slow disease that, in many cases, is associated with repetitive, mild brain impacts. Mild or not, it is still a type of concussion and is known as a disease of aging. With individuals who have experienced CTE, the symptoms start showing many years earlier than other diseases of aging like Alzheimer's disease. Instead of seeing these symptoms when people are in their fifties, sixties and seventies, researchers are now seeing them in individuals who are in their thirties and forties.

Subconcussive hits are essentially asymptomatic. When the players leave the field, they are most likely are not complaining about any symptoms. However, repetitive impacts may force the brain to move around inside the skull. Researchers are not only concerned about that movement, but also what is happening internally to the brain and the chemistry associated with the brain. They have found that, like with concussions, often there is movement and a change in brain chemistry when athletes experience subconcussive impacts.

New technology is being utilized to study the short- and long-term effects of brain impacts. The Boston Research Group has found early signs of CTE in the brains of young football players using Magnetic Resonance Spectroscopy, which shows chemical changes in the brain. These changes indicate when the brain's function has been altered.

Australian researchers have pioneered the development of two-dimensional spectroscopy which shows the chemicals present in the brain with much more clarity than ever before. They are able to identify chemical fingerprints in the two-dimensional spectrum identifying chemicals that are associated with repetitive head injury in rugby players.

Dr. Carolyn Mountford, Professor of Radiology at the Harvard Medical School, who is also associated with the Boston Research Group, set up the Centre for Magnetic Resonance in Health in New Castle, Australia. Researchers there have been able to examine and monitor brain chemistry. Their findings to date indicate that repetitive hits to the head do in fact cause a difference in brain chemistry. They are in a position to now examine an athlete's brain before and after a head injury. To this end, these researchers are also using functional Magnetic Resonance Imaging (MRI), Diffused Tensor Imaging and (1)H-MR Spectroscopy which can predict the outcome of an individual's concussion and should provide novel and expanded research into the understanding of head injuries, whether they be subconcussive or concussive.

The Murdock Children's Research Institute in Melbourne, Australia reported that approximately one-third of the school-age children and adolescents have been found to suffer head injuries when they were admitted and examined in the emergency room.

Professor Mark Stevenson of the Monash Injury Institute in Victoria, Australia, believes that head injuries occurring in his country is a hidden epidemic among non-professional sports. He also discovered that players who have received a head injury the season before were twice as likely to be injured again the next season. There was no differentiation between cumulative subconcussive head injuries versus actual concussions (Stevenson, 2009, 2011).

In the past, soccer has taken a back seat to the National Football League (NFL) with respect to head injuries and has also received less press about the very serious topic of brain damage. Although there have been voluminous reports on concussions in the NFL, there have been only a handful of studies pointing out a distinct possibility of brain damage arising from soccer. One of the risks of brain injury in soccer comes from the ball itself. Many scientists now believe that brain damage can occur from subconcussive impacts as well as concussions. As discussed, subconcussive impacts (which can occur from heading a soccer ball) are simply impacts to the head that are not hard enough to cause a concussion but are hard enough to jar the brain and cause some observable changes and damage.

A 1998 report by Drs. Sortland and Tysvaer in *Neuroradiology* studied 33 former soccer players for the National Football team of Norway. The report concluded that atrophy of the brain was probably caused by repeated small head injuries during the soccer play, mainly in connection with heading the ball (Sortland, *et al.*, 1998).

Researchers have also made other findings concerning soccer players:

a. Increased neurologic symptoms such as headaches, heading related migraine, neck pain, and dizziness (Tysvaer, *et al.*, 1981, 1989; Barnes, *et al.*, 1998; Boden, *et al.*, 1972);
b. Neuropsychological changes in soccer players as compared with hospitalized controls (Tysvaer, 1991);
c. Neurodiagnostic findings of ventricular changes and atrophy in 10% to 33% of former soccer players (Sortland, *et al.*, 1989);
d. MRI changes in nine of 20 members of the U.S. National Team, some with focal atrophy (Jordan, *et al.*, 1996); and
e. More frequent abnormal electroencephalographies in active male soccer players as compared with male non-athletes (Tysvaer, *et al.*, 1989).

Dr. Michael Lipton, of the Albert Einstein College of Medicine, stated in a more recent study that "repeated heading could set off a cascade of responses that could lead to degeneration of brain cells." In Dr. Lipton's study, he assessed the brains of 32 amateur soccer players. The average age of those soccer players was approximately 31 years old and each player reported having played soccer since childhood. Dr. Lipton found compelling evidence of brain changes that look similar to traumatic brain injury resulting from heading a soccer ball with high frequency. He further opined that given soccer's popularity worldwide given children's extensive participation in the sport, these are findings that should be taken into consideration in order to protect soccer players (Lipton, et al, 2009)

Although much more research is needed concerning the long-term effects of heading soccer balls, a number of other studies have drawn a causal link between the dangers of playing soccer and the diagnosis of early onset Parkinson's disease, including players diagnosed as early as 35 years of age. Other players have been diagnosed with early onset amyotrophic lateral sclerosis, behavioral and cognitive problems, depression and many neurological deficits as a direct result of suffering repeated subconcussive impacts during their soccer careers.

As the information involving head injuries and concussions becomes more widely known, parents may think twice before signing their children up for soccer teams which require their players to head the ball during practice and in games. It certainly would not be unreasonable for parents to specify that their children not be involved in heading until they learn more about the brain. There are no published reports of professional athletes suffering from CTE in large numbers. However, that does not rule out cognitive impairment due to subconcussive impacts.

A study performed at Purdue University monitored high school football players for two seasons using helmet-sensor impact data from each player. This data was compared with brain imaging scans and cognitive tests performed before, during and after each session. Researchers also evaluated players using functional magnetic resonance imaging (fMRI), which indicate the parts of the brain which are most active during specific tasks, along with computer-based neurogenative screening tests. The helmet sensors indicated that the impact forces to the players' heads ranged from 20 Gs to more than 100 Gs. A soccer player heading a ball experiences an impact of about 20 Gs (Breedlove, *et al.*, 2010, 2012).

It was found that these players were adapting their mental processes to deal with brain changes. These researchers believe that the changes in brain activity suggest that a player has to use a different strategy to perform a task, and that is likely because functional capacity is reduced. Moreover, the level of change in the fMRI signal is significantly correlated to the number and distribution of hits that a player takes. Lastly, the researchers concluded that performance does not change, but that brain activity changes, showing that certain areas are no longer being recruited to perform a specific task. Dr. Eric Nauman, an associate professor of mechanical engineering and an expert in the central nervous system and musculoskeletal trauma, stated that the most important implication of these new findings by researchers at Purdue University is the suggestion that a concussion is not just the result of a single impact, but instead is really the totality of impacts which took place over the course of a period of time. Dr. Nauman further concluded that the subconcussive impact which brought on the concussion is arguably the "straw that broke the camel's back."

Brain scans in the Purdue University study also showed differences among high school football players over the course of a two-year period, suggesting that concussions are likely caused by many hits over time and not by a single blow to the head, as commonly believed.

Most clinicians would say that if an athlete does not have any symptoms of a concussion, then there are no significant, treatable issues. However, Dr. Larry Leverenz, an expert in athletic training and a clinical professor of health and kinesiology at Purdue University, has found that there is a significant change in brain activity and behavior, even when an athlete does not exhibit symptoms of a concussion (Leverenz, et al, 2010, 2012). Purdue's investigators found that 17 of the football players that they examined showed noticeable brain changes even though those players did not receive concussions. The researchers have now expanded their studies to include girls' soccer to ascertain whether females are affected differently by concussive and subconcussive impacts than males and to study athletes who do not wear protective headgear.

The research findings published by the Purdue University research team present a significant issue with respect to head and brain injuries in sports. Their research suggests that athletes may suffer a form of injury that is extremely difficult to diagnose. This is especially important for young athletes because the brain is still developing. Even though subtle unexpressed damage does not manifest itself as a concussion, it could affect the youth's brain later in life. These researchers opined that there is definitely a buildup of damage before a concussion occurs. Although it is impossible to predict when the final insult may occur, it becomes even more critical to take proactive measures to prevent it.

Dr. Steven Broglio, Director of the Neurotrauma Research Laboratory at the University of Illinois, Urbana-Champaign, has found that multiple subconcussive or concussive traumas to the brain will produce a decline in brain function. Dr. Broglio's research involved 160 controlled subjects with no history of concussions and 62 controlled subjects who had a prior history of concussions. Dr. Broglio used balance and walking assessments along with brain electricity studies. The research was a foundation for "hit count" proposals and his work demonstrated electroencephallographic and motor control changes in otherwise healthy individuals with a history of concussions. Dr. Broglio hypothesized that subconcussive head impacts as well as concussive impacts set about a cascade of pathological events that accelerated declines in cognitive function typically associated with the aging process. This study was the first to quantify improvements in the sensitivity biomechanical measure to incidents of concussion when impact location is considered. The results of Dr. Broglio's research also suggested that each player may have a unique head injury tolerance that is reflected in the distribution of impact severity measures for all non-injurious impacts for that player. He found that certain subject athletes sustained high magnitude head impacts frequently and did not sustain a concussion while others sustained a head injury after relatively few and minor head impacts (Broglio, *et al.*, 2007).

Dr. Andrew Lees, an English neurologist and author, extensively studied the case of Ray Kennedy, who played professional soccer in the English Premier League from 1968 to 1984 and retired from the game at the age of 32, having already started to feel the effects of Parkinson's disease. Dr. Lees concluded that Kennedy's illness could have been detected 14 years before he was diagnosed at the age of 35 using the medical technology available at that time (Lees, 1993). Jeff Astle, another professional English soccer player, died suddenly in 2002 at the age of 59. The coroner determined that the cause of death was a degenerative brain disease and failing mental ability in Astle which had first become apparent as much as five years earlier. During his professional career, Astle was considered an exceptional header of the ball and the coroner found that the repeated subconcussive impacts had been the cause of his death. While the leather soccer balls used in Astle's playing days were significantly heavier (especially when wet) than the soccer balls used today, the minor head traumas that led to his death must be noted.

C. **A Method for Significantly Absorbing, Reducing and Dissipating Subconcussive Impacts**

Although it may seem obvious, most people who allow their children to participate in soccer and other contact sports are unaware that minor, repetitive brain impacts can cause long-term damage. There is documentation that continuous or additional sub-concussion level impacts can result in long-term neurological deficits that manifest themselves during the playing time or after the individual is retired from the sport. In fact, subconcussive impacts can easily result in reducing the threshold of temporary and/or permanent brain injuries.

Rather than chemically or medically intervene with the injured brain, I have invented and patented a protective sweatband for the sport of soccer that reduces the risk and severity of head impacts to soccer players and participants in many other activities (Abraham, 2001, 2002, 2004, 2005, 2009). The gamut of activities and test data associated with the protective sweatband can be found at www.forcefieldheadbands.com. The sweatband can be worn for a variety of sporting activities. It comprises inserts based in helmet technology for the purpose of reducing the severity of the impact forces. Unlike a typical headband, it also incorporates protective inserts of a semi-rigid material within the tubular band.

In independent studies, the ForceField FFTM Protective Sweatband was found to reduce the severity of impact forces to the head and brain up to 80% for children and over 50% for adults. After six months of independent testing, it was awarded a CE II Mark in Europe and designated as "protective headgear." To emphasize the intent of the product, it does nothing more than to reduce the magnitude and severity of the impact forces to the protected areas. In addition to absorbing and dissipating impact forces to the head and brain, the product acts just like an ordinary sweatband; it breathes and absorbs and dissipates perspiration.

From a qualitative standpoint, reports by coaches in high schools and colleges have stated that, for the first time, there has been a significant reduction in head injuries on their teams and that the downtime for those types of injuries has been greatly reduced. In most instances, there was no reported downtime on women's soccer teams due to brain injuries. This may establish that the findings and reports by researchers at Purdue University are accurate and that subconcussive impacts play an extremely important role in causing significant and long-term brain injuries. The utilization of the ForceField FFTM Protective Sweatband, an intervening and proactive method for reducing the effects of the severity of impacts to the brain, will reduce the number of reported brain injuries as a function of the effectiveness of the intervening protocol.

Furthermore, we know that young athletes are more at risk for concussions due to their disproportionately large head size compared to their body size and weakness of their neck musculature. Young children recover more slowly from subconcussive and concussive insults than adults and their brains continue to develop and mature, laying down myelinated fiber tracks until they are in their mid-twenties. Protective sweatbands would be a partial intervention and answer to reducing the severity of impacts to children's brains.

A "baseline" neurocognitive test measures things like visual and verbal memory, reaction time and cognitive processing speed prior to an injury. It provides a "before" snapshot for doctors treating a patient with a concussion to help determine when he or she has fully recovered. The baseline test does not measure a level or effect of prior subconcussive injuries. The accuracy of those tests may be questionable since many medical specialists have found young people having concussive symptoms well after a year has passed. There have been many concussed soccer and other sports players that have consistently passed the test and continued to play until their brain injuries forced them to retire. If that is the case, how reliable is it especially in testing subconcussed and/or asymptomatic brain injured younger athletes whose brains are still developing?

The Fédération Internationale de Football Association (FIFA), the international regulating body for the sport of soccer, and the United States Soccer Federation (U.S. Soccer), the official governing body of the sport of soccer in the United States, do not endorse the use of protective headgear but allow it under certain strict conditions. While the use of shin guards is compulsory by both organizations, they only permit the use of protective headgear when its material make-up is *completely* soft, has memory, and does not interfere with heading the ball.

In contrast to the compulsory use of shin guards to protect the shins, protecting the brain is merely optional. The brain is the most important part of a body. It controls everything we do. Why should protecting the brain be an option? Since when are shins more important than a child's developing brain?

Anson Dorrance, coach of the women's soccer team at the University of North Carolina and winner of 19 national championships, noted that the compulsory use of shin guards did not change the nature of soccer contrary to the initial objections by the officials. Dorence predicts that protective headgear will not change the game of soccer either.

Coaches, athletic trainers, parents and schools at all levels have a non-delegable duty to protect and look after the safety and welfare of children whose brains are not fully developed and have been proven to be susceptible to subconcussive impacts. Researchers have proven time and time again that there are changes taking place in the brain when young individuals are exposed to subconcussive impacts. If the technology allows for the invention and development of non-intrusive headgear that is capable of reducing the severity of impacts to the head and meets FIFA's requirements, one would think that officials responsible for the safety, welfare and health of the millions of children would require that protection of the brain be included as a necessary precaution.

With no scientific or medical rationale, neurosurgeons have asserted that three concussions are sufficient to cause lasting impacts on the brain. However, as we all know, there have been reports of children receiving one concussion and having symptoms for years after the initial insult. It is utter nonsense that parents should expose their children to the possibility of two or more concussions. No one should assume anything about a child's brain nor the accuracy of the theory that a child can suffer three concussions before a parent believes that "enough is enough." Phillippe Pinel once opined that, "a wise mom is cautious how she becomes the echo of a commonly received opinion." *Especially, if that opinion is incorrect*.

I have solved part of the problem in reducing the severity of impacts to the head with an inexpensive, patented headband that is also internationally designated as a protective sweatband. The CE II Mark designates the headgear as protective headgear. The industry recognizes that there is no headgear manufactured or available anywhere in the world that can eliminate concussions. However, if the magnitude of subconcussive hits can be effectively and significantly reduced, it becomes wholly unnecessary to compromise a child's brain. Respected researchers have found that subconcussive impacts can damage the brain even though the young person is observed to be asymptomatic. Allowing continuous subconcussive impacts to occur without protecting a developing brain would be contrary to acceptable and rational thinking.

The potential for long-term brain injury due to exposure to a number of subconcussive impacts to the brain, directly or indirectly, could present a major medical and public health concern because of the millions of soccer players worldwide. Of even more concern are the millions of soccer players who have already been subjected to repeated subconcussive impacts who will not become aware of the long-term effects until many years into the future. Any detrimental effect can manifest itself and become clinically evident in the future.

It should be noted that exposure to subconcussive head trauma may not significantly affect everyone. However, for the segment of young children whose brains are affected by subconcussive head contacts, it is presently unknown what types of cognitive issues they will face in the future. If sports officials can intervene by using protective headgear that will not interfere with the game and, at the same time, significantly reduce the direct impact forces to the brain of young children, it seems incredulous that children should be placed at risk. If one concussion can have long-term effects, including learning difficulties and other issues that impact the child's overall quality of life, one must ask: is it worth the risk of not protecting the brains of young children? No one is immune to head injuries in soccer or other contact or collision sports.

While many researchers believe that small repetitive subconcussive brain injuries in young children can manifest themselves during their playing time or after they have stopped playing, it can also affect their quality of life in later years. Most parents of these young children, their coaches, league officials and school officials are not privy to this information. More importantly, subconcussive impacts can easily result in reducing the threshold of temporary and/or permanent injuries. As such, even if a specialist incorrectly asserts that subconcussive impacts may not lead to lasting effects, the fact that subconcussive hits can lower the threshold for a concussive impact should be worrisome to us all.

In the field of products liability involving the development of a product that could pose a risk of harm to the consumer, it is the non-delegable responsibility of the manufacturer to perform a risk analysis on that product prior to placing it in the stream of commerce. Using the available technology, the manufacturer must design out all of the inherent risks associated with the foreseeable uses and misuses of the product. If that is not feasible, then the manufacturer must create warnings and instructions for that product so that the risks can be reduced and/or eliminated. If that is not done and a consumer is injured, the manufacturer is liable for all of the injuries and damages.

The same principles hold true in sports. If the individuals in charge of the young athletes are on notice of how to reduce the risk of brain injuries and fail to avoid and/or minimize those risks and children under their care are injured, then that child was exposed to an enhanced risk. The coach and the league could be legally responsible. All of the people associated with the sport of soccer have the same opportunity to minimize these risks. The question is whether they will be rational and look after the safety and welfare of the young children or blatantly ignore the research and findings of respected medical researchers and scientists.

References

1. Biomechanical Correlates of Symptomatic and Asymptomatic Neurophysiological Impairment in High School Football. Evan L. Breedlove, Meghan Robinson, Thomas M. Talavage, Katherine E. Morigaki, Umit Yoruk, Kyle O'Keefe, Jeff King, Larry J. Leverenz, Jeffrey W. Gilger, Eric A. Nauman, *Journal of Biomechanics*, vol. 45, no. 7, pp. 1265-1272, Apr 2012.
2. Functionally-Detected Cognitive Impairment in High School Football Players Without Clinically-Diagnosed Concussion. Thomas M. Talavage, Eric Nauman, Evan L. Breedlove, Umit Yoruk, Anne E Dye, Katie Morigaki, Henry Feuer, Larry J. Leverenz, *Journal of Neurotrauma*. Oct 2010, online ahead of print.
3. Neurocognitive Performance of Concussed Athletes When Symptom Free. Steven P. Broglio, PhD, ATC, Stephen N Macciocchi, PhD, ABPP, and Michael S Ferrara, PhD, ATC.
4. Beaulieu, C. L. (2002). Rehabilitation and Outcome Following Pediatric Traumatic Brain Injury, 82 Surgical Clinics N. AM. 393.
5. Jeanette, R. M. (2001). Predictors of Outcome in Severely Head-Injured Children, 29 Critical Care Med. 534.
6. Thomas W. McAllister, MD American Academy of Neurology, May 16, 2012
7. Abraham, C. J., Impact and Energy Absorbing Product for Helmets and Protective Gear, US 6,378,140 April 30, 2002
8. Abraham, C.J., Apparatus For Enhancing Absorption And Dissipation Of Impact Forces For Sweatbands (filed August 22, 2002 Appl. No. 10/225,866), U. S. Patent No.: 6,675,395, Jan.13, 2004.
9. Abraham, C.J., Apparatus For Enhancing Absorption And Dissipation Of Impact Forces For Sweatbands Used In Connection With Helmets (filed June 10, 2003 Appl. No. 10/457,856), U.S. Patent No.: 6,978,487, December 27, 2005.

10. Abraham, C.J., Apparatus For Enhancing Absorption And Dissipation Of Impact Forces For Sweatbands (filed November 17, 2005 Appl. No. 11/281,073, published March 30, 2006) U.S. Patent No.: 7,234,174 issued June 26, 2007 (Continuation-in-Part claiming the benefit of the filing date of the August 22, 2002 non-provisional patent application No. 10/225,866).
11. Abraham, C.J., Apparatus For Enhancing Absorption And Dissipation Of Impact Forces For All Protective Headgear: U.S. Patent 6,272,692, Aug. 14, 2001.
12. Abraham, C.J., Registration Certificate No.: 2008/03600 covering Apparatus For Enhancing Absorption And Dissipation Of Impact Forces For Sweatbands (South Africa): Accepted and issued on February 25, 2009.
13. The Role of Age and Sex in Symptoms, Neurocognitive Performance, and Postural Stability in Athletes After Concussion. Tracey Covassin, PhD, ATC , R.J. Elbin, PhD, William Harris, MS, Tonya Parker, PhD, AT, ATC and Anthony Kontos, PhD, Am J Sports Med June 2012 40 1231-1233;
14. Anderson V., Godfrey C., Rosenfeld JV., Catroppa C. 10 year outcome from childhood traumatic brain injury. International Journal Of Developmental Neuroscience 30 : 217 - 224(2012)
15. Hollis, S., Stevenson, M., McIntosh, A., Shores, E., Finch, C., 2011, Compliance with return-to-play regulations following concussion in Australian schoolboy and community rugby union players, *British Journal Of Sports Medicine [P]*, vol e, BMJ Group, United Kingdom, pp. 1-6.
16. Hollis, S., Stevenson, M., McIntosh, A., Li, L., Heritier, S., Shores, E., Collins, M., Finch, C., 2011, Mild traumatic brain injury among a cohort of rugby union players: predictors of time to injury, *British Journal Of Sports Medicine [P]*, vol 45, BMJ Publishing Group, United Kingdom, pp. 997-999.
17. Hollis, S., McIntosh, A., Stevenson, M., Shores, E., Collins, M., Taylor, C., 2009, Incidence, risk, and protective factors of mild traumatic brain injury in a cohort of australian nonprofessional male rugby players, *American Journal of Sports Medicine [P]*, vol 37, issue 12, Sage Publications Ic, United States, pp. 2328-2333.
18. Michael J. Asken, PhD; Robert C. Schwartz, MD Heading the Ball in Soccer: What's the Risk of Brain Injury?, The Physcian and Sportsmedicine, Vol 26, No.. 11, November 98
19. Tysvaer AT, Storli OV: Soccer injuries to the brain: a neurologic and encephalographic study of active football players. Am J Sports Med 1989; 17(4): 573-578
20. Dailey SW, Barsan WG: Head injuries in soccer: a case for protective headgear? Phys Sportsmed 1992; 20(8): 79-85
21. Tysvaer AT, Storli O: Association football injuries to the brain: a preliminary report. Br J Sports Med 1981; 15(3): 163-166
22. Barnes BC, Cooper L, Kirkendall DT, et al: Concussion history in elite male and female soccer players. Am J Sports Med 1998; 26(3): 433-438
23. Tysvaer AT, Lochen EA: Soccer injuries to the brain: a neuropsychologic study of former soccer players. Am J Sports Med 1991; 19(1): 56-60
24. Sortland O, Tysvaer AT: Brain damage in former association football players: an evaluation by cerebral computed tomography. Neuroradiology 1989; 31(1): 44-48
25. Jordan SE, Green GA, Galanty HL, et al: Acute and chronic brain injury in United States National Team soccer players. Am J Sports Med 1996:24(2): 205-210 [published erratum in Am J Sports Med 1996; 24(4): 563]
26. Lipton ML, Gellella E, Lo C, Gold T, Ardekani BA, Shifteh K, Bello JA, Branch CA, Multifocal white matter ultrastructural abnormalities in mild traumatic brain injury with cognitive disability: a voxel-wise analysis of diffusion tensor imaging, Journal of Neurotrauma, 25(11): 1335-1342.
27. Lipton ML, Gulko E, Zimmerman ME, Friedman BW, Kim M, Gellella E, Gold T, Shifteh K, Ardekani BA, Branch CA, Not so mild head injury: difusion tensor imaging implicates prefrontal axonal injury in executive function impairment following very mild traumatic brain injury, Radiology, 2009, 252(3)816-24.
28. Lees, A, Ray of Hope:The Ray Kennedy Story, 13 Sept. 1993 Center for the Study of CTE, Sports Legacy Institute Chronic traumatic encephalopathy: neurodegeneration following repetitive concussive and subconcussive brain trauma, Christine M. Baugh, Julie M. Stamm, David O. Riley,Brandon E. Gavett, Martha E. Shenton, Alexander Lin, Christopher J. Nowinski, Robert C. Cantu, Ann C. McKee, Robert A. Stern, McKee AC, Gavett BE, Stern RA, Nowinski CJ, Cantu RC, Kowall NW, Perl D, Hedley-Whyte ET, Price B, Sullivan C, Morin P, Lee HS, Kubilus CA, 30. Daneshvar DH, Wulff M, Budson AE. TDP-43 Proteinopathy

and Motor Neuron Disease in Chronic Traumatic Encephalopathy. J Neuropath Exp Neurol, 2010; 69(9): 918-929.

29. Gavett BE, Stern RA, Cantu RC, Nowinski CJ, McKee AC. Mild traumatic brain injury: a risk factor for neurodegeneration. Alzheimer's Research & Therapy 2010, 2:18.
30. McKee AC, Cantu RC, Nowinski CJ, Hedley-Whyte ET, Gavett BE, Budson AE, Santini VE, Lee H-Y, Kubilus CA, Stern RA. Chronic Traumatic Encephalopathy in Athletes: Progressive Tauopathy following Repetitive Head Injury. J Neuropath Exp Neurol, 2009; 68(7): 709-735.
31. Gavett BE, Stern RA, McKee AC. Chronic Traumatic Encephalopathy: A Potential Late Effect of Sport-Related Concussive and Subconcussive Head Trauma. Clinics in Sports Medicine, 30(1), 179-188, 2011. http://www.bu.edu/cste/files/2011/11/Gavettetal2011ClinSportsMedCTE.pdf
32. Daneshvar DH, Baugh CM, Nowinski CJ, McKee AC, Stern RA, Cantu RC. Helmets and Mouth Guards: The Role of Personal Equipment in Preventing Sport-Related Concussions. Clinics in Sports Medicine, 30 (1), 145-163, January 2011.
33. Daneshvar DH, Nowinski CJ, McKee AC, Cantu RC. The Epidemiology of Sports-Related Concussion. Clinics in Sports Medicine, 30(1), 1-17, January 2011.
34. Stern RA, Gavett BE, Baugh C, Nowinski CJ, Cantu RC, McKee AC. Recurrent sports-related traumatic brain injury and tauopathy. Edited by M. Oria and J. Erdman. Washington, DC: The National Academies Press. 2011 (In Press)
35. Stern RA, Riley DO, Daneshvar DH, Nowinski CJ, Cantu RC, McKee AC. Long-term Consequences of Repetitive Brain Trauma: Chronic Traumatic Encephalopathy. Phys Med Rehabil Clin N Am, 3, S460-S467, October 2011.
36. Daneshvar DH, Riley DO, Nowinski CJ, McKee AC, Stern RA, Cantu RC. Long-Term Consequences: Effects on Normal Development Profile After Concussion. Phys Med Rehabil Clin N Am, 22, 603-670, October 2011.
37. Gavett BE, Cantu RC, Shenton M, Lin AP, Nowinski CJ, McKee AC, and Stern RA. Clinical appraisal of chronic traumatic encephalopathy: current perspectives and future directions. Current Opinion in Neurology, 24, 525-531, 2011.
38. Baugh CM, Stamm JM, Riley DO, Gavett BE, Shenton ME, Lin A, Nowinski CJ, Cantu RC, McKee AC, Stern RA. Chronic traumatic encephalopathy: Neurodegeneration following repetitive concussive and subconcussive brain trauma. Brain Imaging and Behavior, Epub ahead.

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Scott R. Abraham, Esq. was 17 years old when the prototype of a protective sweatband was created. He worked with Dr. Abraham through the testing and optimization of the ForceField FFTM Protective Sweatband, aided in the patent applications, researched subconcussive brain injuries in sports and completed the final editing of this paper. He is admitted as an attorney in New York, New Jersey, California and Washington, DC.