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Concussions and Potential Risks in Children and Adults: Sub-Concussive Level Impacts

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One of the most prevalent, severe and compelling health issues in sports today is a condition that affects athletes of virtually all ages, sizes and types—impacts to the head and body resulting in serious head injuries. Players suffering from frequent concussions to experiencing a sever jolt to the head is an issue becoming more worrisome and frequent throughout the world in every contact sport including, but not limited to, football, ice hockey, soccer, lacrosse, wrestling, boxing, basketball and rugby. In the United States, alone there are more than five-million people who suffer from a traumatic brain injury which is a blow or jolt to the head or a penetrating head injury that disrupts the function of the brain.

In 2008 alone, a traumatic brain injury (TBI) occurred every 16 seconds and a death occurring every 12 minutes. Sports played a big part in those statistics. Among children zero to fourteen years of age, there are approximately 2,690 deaths, 37,000 hospitalizations and 435,000 emergency room visits due to TBIs.

Everyone recognizes the cumulative nature of concussions. Anyone receiving a concussion would be more susceptible to a second concussion at a significantly lower threshold level. It always takes longer to recover from a second concussion and even much longer to recover from a third, if there is a recognizable level of recovery which is questionable.

Young people who receive a concussion show subtle signs of mental and physical problems and even thirty years well after the initial impact that caused that TBI. Many former athletes who have brain injuries in their youth, found that they performed worse than their; uninjured counterparts at memory and coordination tests even though the "minor" changes did not noticeably affect their everyday life or their health until they were older.

There are tens of thousands of children involved in organized sports throughout the world. Children enjoy playing sports and parents enjoy getting them involved. However, just one concussion harms a child for life. Is it worth the risk?

Research recently published online Journal BRAIN, reported that even one major concussion can affect the injured person into midlife and beyond manifesting itself in memory decline, reduced motor skills and much slower reaction time.

Knowing the risks that children and adults will take in the name of sports, it is mind-boggling that parents and children do not understand the risks and the benefits of participating in a contact sport without trying to minimize those risks without losing the benefits. The majority of participants as well as parents pretend they do not exist.

Extensive studies in Canada and North America have documented their findings illustrating that an athlete who has suffered at least one concussion in early adulthood had poor performance in memory test, delayed responses to unpredictable events and were slower at hand-controlled tests than those who never had a concussion. What was even worse was the correlation between the on set of Alzheimer's disease during the aging process.

There is no drug, therapy or exercise that has any beneficial effect on concussion. Athletes wanting to brush of the injury and go back to participate in the sport are usually unaware that they risk a second injury where the threshold of the next concussion is much lower than that of the first.

Many athletes are not aware of the fact that they have suffered a concussion. Losing consciousness is not a prime requirement. In fact, unconsciousness occurs in only 5% of the reported concussions. The remaining 95% include any one of about 20 symptoms. These include confusion, headache, dizziness, feeling dazed (ding), vomiting, and poor concentration.

In general, if a repeat concussion occurs before the first one which can be hours, days or weeks, the risk of having long-term problems is significantly increased. Repeat concussions can sometimes lead to brain swelling, permanent brain damage and even death.

It was reported in "Pediatrics" (January 2009) that fewer than 50% of athletes understand the problems that can arise from concussions. In a study of high school teams in Minnesota, the article stated that 69% of players who lost consciousness and 81% of those who sustained a concussion returned to play the same day. This is contrary to the protocol accepted in any sport and it h also contrary to sound medical practice.

Competition throughout the United States has intensified in all youth sports. As a result, children and young adults get mixed messages from parents who call from the sideline, "Shake it off!"

Repeated impacts below the threshold of a concussion can also have an effect on the brain both long term and short term. The long term occurs when the repeated impacts were more

than sufficient to produce a concussion and an impact level well below the threshold have, in some way, had an effect in the reduction of the force at which the concussion is initiated. This mechanism has not been investigated to date. However, not one neurologist or neurosurgeon has been able to dispute the fact that repeated damage to a large number of neurons can aid in the causation of a concussion which may follow.

The Brain

The brain is the body's command center. An adult's brain weighs approximately 3 pounds or 2% of their body weight. The brain requires fuel. The brain can burn up to 70% of the body's glucose (sugar). Most of that energy is consumed by the brain's 100 billion neurons sending signals to other neurons, cells and glands at velocities up to 200 miles per hour. Losing a small amount of brain tissue in an accident can result in drastic consequences and injury to even small areas of the brain due to a stroke and can affect the ability of an individual to speak and even move. In fact, there isn't any part of a brain, if damaged that will not manifest itself in some loss of function to the injured person.

There are no unused areas of the brain. The brain's 100 billion neurons continue to fire off signals to other neurons controlling your heart rate, keeping your body warm, allowing your eyes to blink, the digestion of your breakfast sandwich and the balancing of your body so you do not fall over sideways. AH of the major parts of your brain which includes the front, mid and rear, including their subsections and glands, are always active. There is no part of the brain that is idle at any time. When you learn how to do something new such as play the piano, hit a new serve in tennis or even solve a mathematical problem, new connections are grown between brain neurons. In fact, vigorous physical exercise like running can also stimulate the growth of new neurons and connections resulting in even more brain cells.

Recent results of a study by researchers Charles Hillman and Steven Broglio both professors of Kinesiology and Community Health have found that concussions are linked to suppressed brain functioning years after the injury. The study is reported in the Journal of Neutrotrauma.

The University of Illinois professors " were able to show that while our (their) group of club and intercollegiate athletes, who were on average 3.5 years post-injury, performed normally on standard tests a sports-medicine practitioner would use to diagnose and evaluate someone for concussion, they had suppressed brain functioning." Professor Broglio also stated "... that included a decrease in attention allocation to things going on in their environment."

Recent data coming out of the National Football League in the United States documented that retired athletes who have had several concussions over their career have increased rates of depression, mild cognitive impairment and early onset of Alzheimer's Disease.

Many researchers have concluded that people who have incurred concussions may be at greater risk for cognitive impairment.

Recent studies have showed that life-long damage concussions inflicted on young athletes' brains previously thought to affect career athletes, was detected in the brain of an eighteen year old football player. The disease, chronic traumatic encephalopathy, can initially cause memory impairment, emotional instability, erratic behavior, depression, and/or loss of impulse control before developing into Alzheimer's-like dementia. Up to this point, investigators and researchers do not know how many hits and how much force the head can sustain before the disease takes hold. Signs of the disease had not been previously detected in anyone younger than thirty-six.

Incidents are not limited to high-impact sports like hockey and football. Other sports such as soccer and basketball are well represented in those statistics. These injuries are not just limited to boys. Young girls also end up suffering concussions. In soccer, young girls suffer more concussions than boys. The main problem is that many of these head injuries go unreported and the problem has become a silent epidemic. For example, Dr. Joseph Dongeni of Ohio found, in his research, that 80% of concussions go undiagnosed.

<u>What is a Concussion?</u>

There are a number of definitions for a brain concussion. It is essentially an alteration of consciousness by a force that can be a force hitting a head or falling to the ground. It can also be defined as a harrowing brain injury caused due to a violent blow, shaking or spinning. Such an injury is traumatic causing a transient loss of brain activities and imbalances to the cognitive symptom of the patient. There is no full-proof way of preventing a concussion. It is unfortunate, but true, that during a game, athletes get so hyped that they tend to ignore the severity of a blow to the head or the body which can also affect the brain. In the end, many professional football players, for example, who suffered concussions during play, suffered severe emotional and behavioral problems after their playing days were over, often culminating in erratic behavior, drug abuse, suicide and/or overdose.

Ignoring signs and symptoms of a concussion is extremely serious and can result in long-term deficits-immediate and in the future. Receiving an impact to your head or even a whiplash effect from a hit can result in a concussion. One does not have to lose consciousness to have a concussion. Subtle signs and symptoms such as headaches, dizziness, light-headedness, nausea, ringing in the ears, irritability and difficulty remembering events should be respected as indicators that a brain injury has occurred.

The player should discontinue and reframe from playing all sports and other physical activity until an experienced Medical specialist assesses them and all medical tests document that all symptoms are completely alleviated before returning to any activity or contact sport. Failure to follow this recommended protocol may be devastating to that athlete if a second impact occurs resulting in another brain injury.

Contact Sports

The more you receive a heavy impact or the more you hit, the higher the risk the athlete has in receiving a concussion. A young person's brain cannot withstand impacts that cause concussions over a sustained period of time with little chance to rest. For example, playing more than one game in a contact sport per week may be a recipe for disaster.

Protective Equipment

Protective equipment is designed to reduce the risk of injury, but only if it its properly, is worn correctly and its quality is maintained throughout the season. Each player should also wear a mouth guard every time they play. The mouth guard will help protect damage to the teeth and "potentially" reduce impact causing concussions and jaw fractures. They also help protect soft tissue injuries to the lips, cheeks and gums.

Soccer Injuries

Head injuries have been shown to account for between 4 and 22% of soccer injuries. A.T. Tysvaer has reported in Sports Med. 1992 Sep: 14 (3:200-13, titled "Head and Neck Injuries in Soccer. Impact of Minor Trauma," that clinical and neuropsychological investigations of patients with minor head trauma have revealed organic brain damage. Sixty-nine (69) active soccer players and thirty-seven (37) former players of the Norwegian National Team were included in a neurological and electroencephalographic (EEG) study to investigate the incidents of head injuries mainly caused by heading the ball. Three percent of the active and 30% of the former players complained of permanent problems such as headache, dizziness, irritability, impaired memory and neck pain. Thirty-five percent of the active and 32% of the former players had from slightly abnormal to abnormal EEG compared with 13 and 11% matched-controls respectively. There were fewer definitely abnormal EEG changes among typical "headers" (10%) then among "non-headers" (27%).

"In addition the former players were also subjected to cerebral computed tomography (CT), a neurological examination and a radiological examination of the cervical spine. One-third of the players were found to have central-cerebral atrophy and 81% was found to have from mild to severe (mostly mild to moderate) neuropsychological impairment. The radiological examination of the cervical spine revealed a signiicantly higher incidents and degree of the generative changes than in a matched control group." A.T. Tysvaer has reported in Sports Med. 1992 Sep: 14 (3:200-13, titled "Head and Neck Injuries in Soccer. Impact of Minor Trauma."

In addition to the above, soccer players are getting kicked and injuries to their growth plate at the location of their ankle. ForceField LLC has created a protective wrist and ankle band that protects both the growth plate of the ankle as well as the wrist.

American Football Injuries

As the high school, college and professional football players get bigger, faster and stronger, it is only natural that the tackles have become more powerful. There is no surprise with the vast number of concussions reported daily and weekly during the playing season.

In the early part of the twentieth century, players wore leather helmets. In 1939, plastic football helmets were first introduced by the Riddell Company and are still used today. The purpose of a helmet is to reduce the effect of the impact of a blow to the head as much as possible. When a linebacker unleashes as much as 1,500 pounds of tackling force to a quarterback or another player, the job of the pads and helmet is to dissipate that force so that the "impact" doesn't affect one particular part of the body too strongly. That is especially important when dealing with the head and the brain.

It is important to note that all helmet manufacturers are very quick to "warn" that no helmet is guaranteed to stop a concussion from occurring. Over the years significant strides have been made to make them safer. The main objective in designing the helmet is to reduce and/or eliminate subdural hematomas. It is impossible to eliminate a concussion using any type of helmet for any sport.

If one looks at the basic shape of the helmets used in football, ice hockey, and men's lacrosse, the basic shape is rounded so when you have two rounded surfaces hit each other, there is an anticipation that the impacts will glance of each other.

Over the years we have had water-filled helmets that had bladders inside of them with water, suspension helmets which had just a little harness inside and the helmet sat on top of the harness with air between the head and the helmet, foam such as thermoplastic urethene (TPU) has been the standard for over twenty-ive (25) years.

Riddell's Revolution helmet uses a protective shell that extends to the jaw area and a padding system that inflates and could be fitted to a player's head. Their Revolution IQ Hits can wirelessly relay real-time data to a sideline computer that can send a pager alert when a player receives an impact that exceeds a certain magnitude.

The XI helmet manufactured by Zenith LLC relies on eighteen thermoplastic shock absorbers filled with air that adapt depending how hard someone receives a "hit." A single hole is supposed to allow air to expel and the absorber to compress fully on all impacts. By churning the air into a turbulent state, the absorber stiffens for large impacts and allows air to low out more easily on smaller hits.

Rugby

It was recently announced in the Rugby Union News that the Wasp's captain Raphael Ibanez announced his retirement from Club Rugby. He was forced to retire after a period of rest and recuperation after a series of complex concussions. Mr. Ibanez sustained his initial concussion against the Worcester Warriors in September of 2008. He also suffered further head injuries against Leinster in Dublin and Sale at Adams Park early in the fall season. Ibanez attempted to gradual integrate back into training however, he was still symptomatic when undertaking physical exertion. The neurosurgeon and neurologist for the Wasps during the week of February 9 recommended that he stop playing immediately as the risk of serious injury was too great to warrant any attempt to play again. Mr. Ibanez was 36 on the day of announcement, Tuesday, February 17, 2009. From the time he joined in 2005 to the time of his retirement, he had enjoyed great success as part of the Wasps.

Neurologists and neurosurgeons have consistently reported at international meetings on concussions that there was a high incidence of concussions reported in the sport of rugby. It has been recently reported by the University of New South Wales that using the standard permitted rugby head gear did not stop concussions nor did it reduce the rate of concussion or head injury to rugby union players.

The study was led by Dr. Andrew Mclntosh, a biomechanics expert in the UNSW School of Risk and Safety Sciences, working with colleagues at the University of Melbourne, the University of Ballarat, the University of Otago and Monash University. The research was funded by the International Rugby Board (IRB) with support from the Australian Rugby Union.

The findings, published in the journal *Medicine & Science in Sports & Exercise*, detail how a team of researchers monitored the on-field performance of more than 4,000 players aged between 12 and 20.

Dr. Mclntosh that, "Skull fractures and intracranial bleeding are rare in Rugby injuries, but concussion is relatively common ... There's some evidence that the standard headgear may prevent some minor head wounds but our study found that it was of no benefit in preventing concussion."

Wrestling

On February 17, 2009 it was announced that the New Jersey state champion, Jeffrey Francis, a three-time state finalist-including a state title in 2006-was placed in the doubtful category in competing in his fourth state tournament.

He entered the MRA Wrestling program as an 85-pound eighth grader. He was recently wrestling when he obtained his title in 2006 at 125 pounds. Mr. Francis has struggled with

concussions at the end of last season (2008) and received another one at the Black Horse Tournament in Memphis this season.

Boxing

A large number of high-profile boxers over the recent years have died after being diagnosed with Alzheimer's. Former heavy-weight champions Floyd Patterson and Ingmar Johansson are among the most recent examples. There is no documentation stating they died of Alzheimer's. It is important to note that Alzheimer's was directly related, with high probability, to the constant pounding each of the boxers received throughout their career. The much publicized Parkinson's Disease ended up destroying Mohammad Ali's quality of life after a successful boxing career. It is highly predictable that every boxer during a match receives blows above the threshold level for concussions and many impacts that are close to the concussive threshold. It is predictable in both situations that each impact results in some level of head injury.

Ice Hockey Injuries

More than one-third of soccer players on the Norwegian team had abnormal brain scans, perhaps partly from heading the ball.

A small study of 40 former athletes who had played contact sports, ice hockey or American football at the university level, showed that 19 of the 40 who reported being concussed were slightly worse at memory tests and were slower at a coordination test requiring them to rotate objects. This was reported on the BBC. It was also possible that the athlete, who was generally left-coordinated, might be more prone to concussion and poorer performance at physical test.

Dr. Lewis De Beaumont and his colleagues from the Center of Research in neuropsychology and cognition, tested sports igures thirty years after their concussions occurred. Their ages ranged from ifty to sixth ive years. Fifty of the ifty-six volunteers played for a Canadian University ice hockey team and six had played for American football teams. All volunteers had no history of alcohol or drug abuse, no major medical or psychiatic illness, no concussion reported since their time with the university team and all were still physically active exercising at least three times a week. Forty-six of those volunteers met the criteria and six of those could not recollect the concussion event in suficient detail. The average age of that group was sixty one years.

The concussion ranged in seveity from episodes of confusing without lose of consciousness to prolonged loss of unconsciousness for several minutes. Twenty-one of those volunteers had no history of concussion and were used as the controlled group. They had an average of fifty-nine years. Both groups had achieved an average of eighteen years of education.

A Mini Mental State Examination (MME) was presented to both the control and the group that had prior TBIs that tested orientation, attention, immediate and short-term recall, language and the ability to follow simple and verbal commands. Reaction times were also tested in addition to muscle tests which examined their coordination.

The results showed that former athletes with concussions performed worse on a memory test of recognition. They were also slower in the coordination test. It also demonstrated that former athletes who sustained their last concussion twenty to thirty years prior to the test showed cognitive and motor system alterations when compared to the former athletes who had no prior history of sports concussions. These findings resemble other studies of athletes where the concussion occurred only three years prior to the testing.

Although one may question on how severe a concussion needs to be to leave long-term damage and how much any damage might affect the performance, there is no doubt that all of these studies prove that concussion injuries damaging any part of the brain lead, in some way, to long-term damage affecting the quality of life of the injured athlete.

Although fighting is already against the rules in hockey, it is unofficially sanctioned by the weak penalties against it. The penalties do little to discourage fighting or even make a player stop to think before he drops his gloves in order to "beat up" on his opponent.

It is understood that ice hockey is a contact sport. Aggressive play and body contact is part of the game, but ice hockey is first and foremost a game of skill. Fighting does nothing to further the play.

When hockey is played properly as observed throughout Europe, it is a beautiful thing to watch. The lightning quick moves as the puck travels from one end of the ink to the other, players coordinating their efforts against their rivals as the game changes quickly from moment to moment. Goons slugging it out on ice skates take away from the greatness of the game.

In comparison, as physical and aggressive that the sports of football and rugby are, rarely you see any of the players fighting one another.

<u>Baseball Injuries</u>

Dr. Stanley Conte, the medical director for the Los Angeles Dodgers, has done extensive research on concussions in baseball players reported that "up to 20% of professional catchers reported concussion symptoms related to being hit by a foul tip despite the fact that the majority of these players were never formally diagnosed as having a concussion."

A Parent's Dilemma

Many parents live through the playing experience of their children hoping that they are never hurt or injured. The most tragic experience a parent can have is when their child is permanently injured i.e., paraplegic, quadriplegic and lastly brain injured.

It was recently reported that Derek Ruth has spent the last six months as of February 16, 2009, relearning thirteen years of lessons. He was a twelve-year-old junior-high student whose life was forever changed after he sustained a traumatic brain injury during a football game in September of 2008.

After he received his head injury, he came to the sidelines and was coherent. He knew the score of the game. Moments later, he collapsed and paramedics flew Derek to an area hospital where the doctors diagnosed that the twelve-year-old had sustained a brain injury. It was later determined that Derek had experienced two subdural hematomas and the surgeons had to temporarily remove two pieces of his skull. Derek has since had to relearn all of the basic motor skills including walking and talking. He has to work to retrain other parts of his brain to relearn those skills so that the skills can be completed as before but in a different way.

There is an inherent risk in almost every contact sport that can lead to traumatic injuries that Derek has experienced. The question is, if that risk is known to the parent and the young participant, is it worth that risk if the individual does not have the potential to excel in that sport to a point where their ability would allow them to minimize their risk of a permanent traumatic injury? The alternative is to expose children to sports and activities that would remain with them for the rest of their lives. Football, like any other team sport, end in high school or in college. Sports such as tennis, golf, cycling, bowling, and running can last a lifetime.

Sub-Concussive Impacts

Based upon the information discussed in this paper, it is important to note the following:

1. **An individual can sustain a concussion even though they are not hit in the head.**
2. **Over 90% of reported concussions do not involve loss of consciousness.**
3. **Every concussion is a type of traumatic brain injury (TBI).**
4. **The most common type of brain injury sustained in sports is a concussion.**
5. **A concussion cannot be seen. However, the symptoms may be visual immediately or even days or weeks later.**
6. **Multiple concussions can cause cumulative, long-lasting changes in the quality of one's life.**
7. **After receiving one concussion, the threshold in receiving the second concussion is significantly lowered.**
8. **Typically, concussions do not appear in neuro-imaging studies such as MRI or CAT Scans.**

It is well documented that an undiagnosed concussion will affect one's ability to function at school, at work and in everyday activities. What has not been studied to date is the repeated sub-concussive effects on the brain.

Based upon all of the research performed in the area of head injuries and concussions it is the opinion of the author that repeated sub-concussive impacts will have a significant effect on the brain with reference to reducing the threshold level of a concussion. The added effect may be directly related to a permanent deficit.

Biomechanical forces that have an impact on the brain directly or indirectly involve acceleration-deceleration (linear), rotational or a combination of both. The nerve cells in the brain (neurons) are stretched and torn by those impact forces. Although there are hundreds of millions of neurons that control all of our activities, regenerated neurons may or may not transmit message? through the same path through the undamaged neurons or through the same path once the injured neurons are regenerated. To date there has been no method that can determine the effect of damaged neurons on the brain and/or the behavior, maturity and learning capabilities of a young person experiencing repeated sub-concussive impacts.

When a person receives a concussion, they are not limping or bleeding, they do not have a cast, they are not walking with crutches and do not appear to be injured. The injured athlete has none of the typical external signs worn by other athletes when they are injured. The same is for the athlete who receives repeated impacts that are sub-concussive. How many of those impacts of a sub-concussive level can an athlete receive before those impacts are manifested in some ways as an "invisible injury?"

When participating in a contact sport, no neurosurgeon or neurologist can document or attest to the fact that an athlete diagnosed with a concussion was caused by one impact rather than a number of sub-concussive impacts causing the reported concussion.

Conclusion

If young athletes like contact sports such as football, lacrosse, soccer, etc. they will have to accept the fact that very strong, very fast, very big people will do each other injuries, repeatedly, to long-lasting effects. Parents, as well as young injured children, have to learn to accept that they can participate and play something else that is equal or better in terms of physical benefit but far less risky. If all of these athletes intend to compete in college or the workplace in jobs that use their brains and not their back, had better pay attention to their future by choosing their activities or participation at a young age.

Receiving mixed messages from parents, coaches and trainers, have not helped the youth in our country from properly monitoring and medically taking care of their head injuries. It

is up to the parents and the injured child to rationalize the risk explaining to them that they cannot organize their life around avoiding injuries as long as they participate in a contact sport If a child does get hit in the head or hit in a part of their body where their brain is affected, is it worth nervously awakening their child for more than a few nights every few hours to check for signs of a brain injury?

Dr. Abraham was a United States representative to the International Standards Organization (ISO), a member of the Executive Board of the Hockey Equipment Certification Council (HECC), a member of the Safety and Protective Equipment of USA Hockey and has been an active member of the American Society of Testing and Materials (ASTM) from 1964 to the present time. He is also a Diplomate in Sports and Recreation Safety.

In addition, he is considered an OSHA specialist in safety and safety engineering. He has an extensive background in the protection of construction workers in every aspect of construction.

In addition to all of the above, Dr. Abraham has over fifty years of experience in polymers and has extensive testing experience in the absorption and dissipation of forces of every type of polymeric material used in headgear. A more detailed description of his background may be found at www.scientificadvisory.com.

In addition to all the above, Dr. Abraham has invented and commercialized many products. One of the products essentially eliminated quadriplegics and paraplegics of young children playing football. He was the inventor of the facemask that changed the sport of football and made it safer. The facemask was licensed to Riddell.

As a result of Dr. Abraham's participation in personal injury and litigation cases, many products have been made safer and have reduced the risk of injury to both children and adult