Technological Advances In Equipment And Concussion Prevention In Football

Concussions and mild Traumatic Brain Injuries (mTBI's) are common injuries sustained while playing football. According to the Third International Conference on Concussions in Sport, a concussion is defined as "a complex pathophysiologic process induced by traumatic biomechanical forces." (Navarro, R. R. (2011).) Similarly, according to Christian Ambler, a neuropsychologist, a traumatic brain injury (TBI) is defined as "a blow or jolt to the head or a penetrating head injury that disrupts the normal function of the brain." (Shaughnessy, M. F. (2009) Concussions and mTBI's can affect different lobes of the brain, which can result in many psychological problems. At all levels of participation, youth to professional, there is an increased effort to reduce the risk of these neurological injuries. I examined many scholarly works to find a solution to these problems and hopefully reduce concussions from occurring among football players. After thorough research, I was able to conclude certain findings that will benefit both the current and future generations of football players. The most effective way to prevent these brain injuries from happening is by utilizing the improvement of technology in equipment. Specifically, improved designs for helmets, which feature new material that is better suited to protect the brain and reduce neurological injuries. Also, the advancement of mouthguards, which can also lead to a reduction in the number of concussions and traumatic brain injuries. Concussions and traumatic brain injuries will never be eliminated from the game of football. However, with the improvement and technological advancements in equipment, these neurological injuries will start to gradually decline.

The first scholarly work that I examined was a journal written by Rodolfo R. Navarro, MD, in the Current Sports Medicine Reports, titled "Protective Equipment and the Prevention of Concussion – What Is the Evidence?" This report observed the effectiveness of protective equipment in preventing concussions across several sports. The protective equipment that was used in this study included mouth guards, headgear, face shields, and customized mandibular orthotics. The sports that were considered for this study were Football, Rugby, Soccer, Field Hockey, and Ice Hockey. This specific study was launched because of the widespread interest that concussions have been garnering and the negative impact they have on youth sports. For the Football study, a customized mandibular orthotic (CMO) was used to monitor the effectiveness in the prevention of concussions and brain injuries in high-school football players. To collect data for this study, players were asked to participate in two surveys. The first questionnaire occurred before the orthotic fitting, and the other questionnaire occurred after three consecutive seasons of using the CMO. I found the results of this study to be very positive. In the two years before using a CMO, there were a reported 59 concussions. After three seasons using the CMO, there were only three reported concussions. The study found that players were 7.67 times more likely to receive a concussion if they did not wear the CMO throughout the football season. That being said, there were some limitations with this study that rendered any results of the trial to be inconclusive. The two main issues with this study were the "lack of randomization of study participants and the lack of a control group." (Navarro, R. R. (2011). Additionally, there was very little enforcement of the actual use of the CMO among these football players. These inconsistencies made it difficult for the authors of this report to confirm any findings that they discovered throughout their experiment. Overall, the study concluded that no current protective equipment was effective in preventing sports-related

concussions. I found these conclusions to be interesting because it suggests that there is a need for new equipment, with different designs, materials, and features. Once these advancements in equipment become available and are proven to reduce sports-related concussions, their use will likely be enforced.

The second scholarly work that I examined was titled “An Examination of American Football Helmets Using Brain Deformation Metrics Associated with Concussions”. Like the previous scholarly work that I examined, the authors of this journal were concerned that current football helmets are unsuitable to prevent concussions and brain injuries. The journal stated that traumatic brain injuries are primarily linked to “peak linear acceleration responses to head impacts”. (Post, A., Oeur, A., Hoshizaki, B., & Gilchrist, M. D. (2013). Linear acceleration refers to the rate of change in velocity per unit of time while on a straight course. Concussions, on the other hand, are closely correlated to “rotational acceleration when both centric and non-centric impacts are used.” (Post, A., Oeur, A., Hoshizaki, B., & Gilchrist, M. D. (2013)). Rotational acceleration refers to the change in angular velocity that a spinning object undergoes per unit of time. Before this study was conducted, there was strong evidence to suggest that current football helmets are designed to prevent traumatic brain injuries. Prior research suggests that materials found in football helmets, such as Vinyl Nitrate foams, Expanded Polypropylene, and polycarbonate shells, are designed to reduce the magnitude of linear acceleration impacts. However, there has been no research on the effectiveness that current football helmets have on the reduction of rotational acceleration impacts and their effectiveness on concussion prevention. Therefore, the authors in this journal wanted to develop a method to accurately test the amount of brain tissue deformation incurred through a centric and non-centric impact, using finite element models. Three different models of football helmets were examined during this experiment, and nine different impact sites were used to evaluate the performance of these helmets. I found the results in this study to be very informative and extremely beneficial for future helmet designs. In conclusion, the study suggests that football helmets should be designed to manage both the linear acceleration and rotational acceleration. The researchers discovered a direct correlation “between the rotational acceleration and level of brain tissue deformation.” They recommend developing technologies that will cause a separation between the helmet and the head to reduce rotational acceleration impact. Research suggests that technological advancements in helmet design could ultimately lead to a reduction of concussive injuries for football players.

Another scholarly work that I studied focused on preventing traumatic brain injuries with liquid shock absorption. The authors of this journal initiated their research because of the growing concern with chronic traumatic encephalopathy (CTE) and its link to contact sports. These researchers defined a concussion as “a clinical syndrome characterized by immediate and transient alteration in brain function, including alteration of mental status and level of consciousness, resulting from mechanical force or trauma.” (Alizadeh, H. V., Fanton, M. G., Domel, A. G., Grant, G., & Camarillo, D. B.) (n.d). During their initial research, the authors discovered that 3.8 million people suffer a concussion from sports and other activities in the United States each year. They also realized that football is the sport that requires an immediate solution because football players sustain approximately 1,000 hits to the head throughout a season. The researchers started their investigation by examining the current materials found in football helmets, specifically the energy absorber liner. The energy absorbers are an extremely important function of helmets, as they are responsible for reducing head acceleration and protecting the brain. The energy absorber liner can be made of either solid, gas, or liquid, and the researchers wanted to find the material which was most effective in preventing concussions.

All helmets today that are currently available for commercial use incorporate ether a solid or gas energy absorber system. Solid energy absorbers include foams, and buckling cones and beams, whereas gas energy absorbing systems include air compression shock. The researchers ran several tests and trials on helmets with all three energy absorbing systems and compared the results of each material. The results of these experiments were very enlightening and I believe it was the most useful study that I researched. Solid and gas energy absorbers were found to be less effective at protecting the brain, due to their deformation-dependent nature. Liquid energy absorbers were found to be very effective at protecting the brain and this corresponded to a 75% reduction in the number of expected concussions. The main difference between liquid energy absorbers is that the force response is more velocity-dependent, as opposed to deformation-dependent. Over the next decade, I hope that helmet manufacturers are only producing helmets with liquid energy absorbers for all levels of football.

The next scholarly work that I researched was focused on the technological advancements of mouthguards. The article titled, “Effect of the Mandible Mouthguard Measurements of Head Kinematics”, examines how mouthguards can accurately measure brain activity upon impact. The authors of this journal believed that other wearable sensors were not as effective as capturing brain activity as mouthguards, mainly because the mouthguard provides better coupling to the skull. The researchers in this journal hypothesized that constraints on the mandible or jaw would affect the accuracy of kinematic measurements. To test their theory, they performed free-fall drop experiments on anthropomorphic test dummies (ATD) and post mortem surrogates (PMHS) with football helmets. They separated their tests into three distinct groups; helmets with no mandibles, helmets with unconstrained mandibles, and helmets with clenched mandibles. The researchers captured data on the angular velocity, angular acceleration, and linear acceleration on six different parts of the brain. After 270 tests were conducted, the results of this experiment because clear and conclusive. From the ATD and PMHS testing, it was concluded that mandible constraint can affect mouthguard accuracy. The researchers of this study and the authors of this journal developed a prototype mouthguard upon their conclusions. They determined that a mouthguard with “kinematic sensors in front of the incisors and EVA material removed from the bite plane at the incisors” was the most effective model. (Kuo, C., Wu, L. C., Hammoor, B. T., Luck, J. F., Cutcliffe, H. C., Lynall, R. C., Camarillo, D. B. (2016). I believe this was a very groundbreaking study to prevent concussions in the future. Advancements in technology have made mouthguards a critical tool in capturing accurate data on traumatic brain injuries.

The last scholarly work that I decided to research was titled “On the Accuracy of the Head Impact Telemetry (HIT) System used in Football Helmets.” The authors of this journal wanted to reduce mild traumatic brain injuries and concussions from occurring in football players at all levels. The HIT uses “helmet-mounted accelerometers to determine linear and angular head accelerations, to assess the severity of helmet impacts”. (Jadischke, R., Viano, D. C., Dau, N., King, A. I., & Mccarthy, J. (2013). The researchers wanted to asses which helmet, medium or large, was appropriate for the Hybrid III head. They hypothesized that helmet fit could affect the accuracy of HIT, and therefore, studies needed to be conducted. Upon completion of the study, it was determined that a medium helmet is not representative of how most players wore their helmets on the field. Although they were seen as the standard in the past, medium helmets exceeded the discomfort level by 35% and produced peak pressure. Whereas the large helmet was determined to be the appropriate helmet because of the low pressure it produced, the Hybrid III head circumference, and the manufacturer’s fitting instructions. That being said, there were a series of errors with HIT in determining head impact severity, and the football community

should be aware of these inconsistencies. Overall, I found this study to be informative and useful in the future of helmets. Over the next several years, I imagine high school coaches will make a big push to have the most advanced, safest equipment for their players. Studies like this can go a long way in determining which helmet will be the most widely accepted among high school coaches and teams.

The research that I conducted was valuable in discovering the optimal solution for preventing concussions in football. Technological advancements have made helmets more equipped to reduce traumatic brain injuries. Also, technology has made it possible for players to wear mouthguards that accurately record the magnitude of the impact. Technological advancements in technology will significantly reduce concussion in football in the future.

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