Medical Xpress

Can headband sensors reduce underreported concussions in kids?

September 15 2016, by Gary Blanchard And Marcos Dantus

In one of the most exciting soccer games of the season, Kelly jumped to head the ball and score, imagining this would be the game-winning goal. Out of nowhere, the goalie jumped and met Kelly's head with both fists. Kelly felt the jolt and landed harshly on the grass. Most of all, she was furious she had been robbed of the opportunity to score.

Next to Kelly, the goalie screamed and got most of the attention from players and coaches because of a broken finger. Kelly wanted to get back on the field. Her teammates and coach asked if she was fine. She said yes and was helped up by her teammates. When she heard the applause from the sidelines she was convinced she was doing right by her team.

Fortunately for her, her coach noticed Kelly was unable to track balls in the air when she was back on the field; she seemed to be squinting and was not smiling as usual. She asked Kelly to sit for the rest of the game. Kelly developed a headache and her coach recommended that her parents take her to the ER to be examined for a possible concussion.

Scenes like this true story, even though Kelly's name has been changed, occur thousands of times every day around the country. With football and soccer in full swing in schools and recreation leagues around the country, it is important to continue to draw attention to the real risk for concussions that youngsters face – and to try to find solutions.

Concussions in football have drawn a lot of attention, but men's and women's soccer account for at least 19 percent of concussive sports injuries. While those of us who study concussions know they are common, we also know they are difficult to assess.

When an athlete has difficulty standing up, walking or talking after a "hit," or collision with another athlete, it is easier to suspect a concussion. Often, however, such an immediate symptom does not occur. A recent study suggested that more than half a million concussions in youth go unreported. Too often, the athlete is asked to provide a self-evaluation seconds after a traumatic brain injury.

Unfortunately, in most cases the outward signs of concussion are subtle and easy to miss. When it occurs a few feet from the ball, it can go unnoticed. The NFL and now the larger collegiate football conferences include spotters and a physician whose primary role is to look out for the player's safety.

This, however, leaves about 98 percent of players in high school, middle school and all youth leagues without the benefit of these safety measures. Between 1.1 million and 1.9 million concussions occur in children each year. That is far greater than the number of children with concussions reported by emergency departments; their records indicate the number ranges between 115,000 and 167,000.

Given the desire of the players to compete and not to disappoint their teammates as well as lack of awareness of the early symptoms of concussion and the importance of avoiding a second concussive injury, many athletes return to playing after having experienced a concussion.

Swelling following a concussion reduces the brain's ability to absorb a second impact. In addition, concussion often results in impaired peripheral vision and coordination, increasing the likelihood of a second impact.

Asking the person who has been concussed to self-diagnose makes little sense. As measurement experts, we sought to come up with a solution to unreported concussions.

Heading off an often debilitating diagnosis

Having kids who participated in youth, high school and college sports, we recognized the need for a simple device that could detect if a player had experienced a blow to the head. Unlike most parents, we collectively have over 50 years of experience in experimental measurement science.

We sought to detect the magnitude and location of the head impact in order to provide information for parents, coaches and health care providers as an aid in determining if a concussion has taken place.

We set out to design a device that could be used as an extension of the clinical evaluation by showing the location and magnitude of a head impact. Given that impact sensing is outside our immediate field of expertise, which involves ultrafast lasers and single layers of molecules, we partnered with Michigan State University's football and soccer athletic trainers and players to evaluate our initial prototypes. From each meeting and trial, we learned what works best, and what simply does not work.

We initially thought of using accelerometers similar to those on smart phones that can sense abrupt changes in direction; however, our experience with sometimes finicky high-tech gadgets and continuously updating operating systems forced us to seek a more reliable platform.

We focused on the use of a recording media that would respond to localized pressure. We then developed a sensor design that could be calibrated so that the measurements would accurately reflect how severe a head impact is. Finally, we tested multiple headbands and skullcaps to come up with a design that would be comfortable to wear.

The help from Michigan State Head Athletic Trainer Dr. Sally Nogle and neurologist Dr. David Kaufman was critically important to capture the essence of the problems encountered in the field.

One of the biggest problems in keeping players safe is that it is hard to keep track of all the players. Therefore, it is important to have a rapid on-site sensor that records the magnitude and location of a head impact. Nogle and Kaufman stressed that only a trained professional can diagnose a concussion. But knowing the location and severity of the impact can help them determine if a player should be kept from returning to the field before a concussion protocol.

The process took 18 months, 200 failed prototypes and several broken accelerometers, which are used for calibrating the magnitude of impact. Ultimately we arrived at a headband or cap design that contains four sensor strips that were used by several football and men's and women's soccer players during the spring 2016 season. The sensor strips have four to six sensors each that are easy to read.

Our sensors measure force, which, according to Newton's second law, equals mass times acceleration. Therefore, unlike accelerometers that are sensitive to motion, our sensors take into account mass and are sensitive to force. In practical terms, this means our sensors are much less likely to indicate false impacts.

When impacted, the sensors show an image that can be understood intuitively: no image for a weak impact, a circle for moderate impact or a circle with a star inside for a severe impact. These sensors have no electronic components, so there is no need to interface them with a phone or computer.

We can't yet disclose all the technology that in the patent-pending sensor strips, which we intend to further develop and sell through a company we formed. The sensor strips are calibrated using a testing system developed to simulate the actual size, shape and weight of a human head attached to a flexible neck.

In addition, industrial electronic accelerometers capable of taking impacts are five to 10 times greater than those associated with concussion are used to calibrate the design parameters of the sensor strips.

We would like to see that their affordable sensors make youth sports safer and minimize the risk of repeated concussive injuries. They would like to know that the next time a soccer player wants to get up and return to the playing field, there will be a way to let coaches, trainers and/or parents know the location and severity of a head impact. This information can help in making a better-informed decision regarding the possibility of concussion. The hope is to put information in the hands of professionals, so that more severe traumatic brain injuries can be avoided.

This article was originally published on The Conversation. *Read the* original article.

Source: The Conversation

Citation: Can headband sensors reduce underreported concussions in kids? (2016, September 15) retrieved 8 May 2024 from https://medicalxpress.com/news/2016-09-headband-sensors-underreported-concussions-kids.html

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