PLTW Grant Proposal

21st Century Mobile SmartPhone Concussion App

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Section I: Purpose Statement and Title

Title:

21st Century Mobile SmartPhone Concussion App

Purpose Statement

High school student athletes need more conclusive testing following a head collision that leads to concussion symptoms. A concussion App for smart phones will enable student athletes to take a cost-effective pre and post-concussion test that will be comparable to those given by a neurologist.

Section II: Project Overview

The testing and understanding of concussions has almost bridged the gap from the damage it is creating throughout sports and combat. Washington was the first state to create laws to protect athletes after one of its student athletes sustained life-threatening injuries (Sports Concussions, 2011). This was a direct result of permitting the student athlete to return to play after displaying concussion symptoms. "Several states have adopted concussion laws over the past two years, designed to protect student-athletes from returning to play without medical supervision, and in some cases, to help reintegrate the student back into complete academic experience after sustaining an injury" (Sports Concussions, 2011). Currently, 27 states have concussion laws in place while 15 other states have laws that are pending including the District of Colombia (Sports Concussions, 2011).

Technology will need to match the laws being passed by legislature. Schools currently have access to expensive testing systems, but these systems lack the integration that would be provided by a comprehensive database. This database

would be used to exchange information on pre and post-concussions between coaches, parents, trainers and physicians. Creating an application for smart phones that will enable all of these individuals to provide and receive test results from pre and post concussion analyses will minimize the long-term damage that is currently ravaging the future of our student athletes.

Section III: Problem Statement

Recent studies into long-term and short-term effects of concussion have brought awareness to parents and coaches about an increasingly problematic situation that occurs every day (Georgia institute of Technology, 2005; Anderson, 2001). The research has raised concerns and initiated a drive to improve testing of presumptive concussions in the field.

"These improvements have been taking place to help relieve the problems, but much is still desired. With an incidence of 300,000 sport-related concussions per year and the potential for catastrophic outcomes, better guidelines for managing cerebral concussions in sports are needed" (Anderson, 2001). The impetus for improved guidelines comes from neurological studies that have found long-term effects result from a secondary incident when a player is allowed to re-enter the game after having mild traumatic brain injury (mTBI). According to Bey, young adolescents have the highest frequency of concussions, which typically result from sports and bicycle injuries whereas in adults the majority of concussions result from vehicular injuries (Bey, 2009).

One of the biggest concerns with brain trauma is when an individual not qualified to assess the situation, misdiagnoses the brain trauma, and the athlete is

returned to competition without time to recover. This could lead to another injury that is emergent in the medical field called “Secondary Impact Syndrome”, which is becoming a big concern for trainers, parents, and athletes. “When a player or soldier with even a mild concussion is sent back to the field, another blow to the head can lead to additional life-long problems or even Secondary Impact Syndrome, which has a mortality rate of up to 50 percent” (Georgia Institute Of Technology, 2005).

These grave concerns have led to a need for a portable concussion test device, which is not only accessible to trainers and doctors in their home offices but also accessible to parents and coaches at the site of the injury. The portable device needs to take all of the technologies that are available to neurological doctors and put them in the hands of any individual with a smart phone. “When suffering from mTBI, a person will have difficulty with certain types of thinking controlled by different areas of the brain, such as working memory, complex reaction and multi-tasking” (Georgia Institute of Technology, 2005). Mainstreaming these tests and putting them on a smart phone as an application will enable access by parents and coaches at any sporting event, even at away locations. All athletes will use the application before a concussion to give physicians a baseline score for comparison if needed at a later date. Another aspect that has not been focused on would be to put the database of test scores on a server that can be accessed by the school, parents and also the student athletes’ physician. This innovative characteristic is unique to our application.

Several groups have put forth possible solutions to the problems that we address here (for a complete review, see Section V). However, their efforts have

fallen short of what is necessary to quickly ascertain if a player can return to the field in a short period of time. These products lack the integration provided by a database, as well as the motor response tools provided by the addition of the Eye Tracker module. Without these tools, the existing products are inadequate.

IV. Product Methodology

From the review of the problem discussed above, it is clear that what is missing is a comprehensive test for looking at mTBI that is always available and affordable to school athletes and coaches. To this end, we propose a two-fold approach to solving this problem.

Goal 1: First, we propose to develop a Smart Phone App that would allow coaches, parents and athletes the tool to administer an mTBI test at the time of trauma, and minimize the chances that a subject suffers from Secondary Impact Syndrome (SIS). **Goal 2**: The second goal of this project is to provide an online database that would contain baseline information regarding all participating athletes.

***Objective 1*: Development of SmartPhone Application**

The first steps in completing this project will be to put together a software development team capable of writing both the Smartphone application and developing the backend Oracle database that would be needed to store and retrieve all of the data. A team of scientists and software engineers would meet with a neurologist to write the software specifications needed to complete this work. The authors suggest using the services of Cimarron Software to write the code, and Dr. Jamshid Ghajar to suggest the best questions to ask the subjects. We would also

contact ImPact to see if we could team up to use some of their already written concussion analysis tests (ImPACT, 2011).

Objective 2*: *Clinicals Assessment Questions

The mobile app would first ask the patient a number of the standard Clinical Assessment Questions that examine the patient's attention, working memory, and executive functions. The app would be initialized by a coach or parent, and then would be handed over to the traumatized athlete to complete the answers. Questions would include those described in Table 1 and would be rated on a severity scale by the affected subject.

Table 1 Subjects would rate their perceived level of the following symptoms:

Headache:	**Feeling Slowed Down**:
Pressure in Head:	Feeling Like "In a Fog":
Neck Pain:	"Don't Feel Right":
Nausea or vomiting:	Difficulty Concentrating:
Dizziness:	Difficulty Remembering:
Blurred Vision:	Fatigue or Low Energy:
Balance Problems:	Confusion:
Sensitivity to Light:	Drowsiness:
Sensitivity to Noise:	(Anderson, 2001)

Additional cognitive tests would use the phone's ability to record responses to visual cues and the time it takes for the subject to respond to them. Tests would include measuring verbal and visual memory, processing speed and reaction time. An example of such a test would be that the App would display a list of numbers or objects, and the subject would be asked to recall and identify the objects in sequence. The App could also play audio clues for the subject to respond to by selecting the correct icons on the Smartphone display. The Smartphone, once the

initial analysis is complete, would upload the baseline data to the Concussion Database. Upon a presumptive concussive event, the test would be re-administered, and the newly uploaded data would be compared to the baseline results. If the anomalies from normal exceed a minimum threshold, the software would declare the patient with mTBI, and the subject should not be allowed to return to the game, and would instead be, referred to a physician for further testing.

Objective 3: Eye Tracking

The second part of he app would focus on using the smart phone screen and the forward facing camera to assess the participant's ability to follow a circle traced on the screen. This technology exists now (Maruta,*et al.* 2010); however, it has not been ported for application on a Smartphone. We feel that the technology has progressed enough that the forward facing camera on a Smartphone will have a sufficient resolution to track and record a subject's eye movement. In order for the camera to accurately track the individual's eye movement, it will be necessary to place three small locating stickers on the subject's forehead and on the left and right lower eye orbits. As the circle is drawn, the video camera in the phone will record the ability of the subject to track the screen.

A subject's eyes with normal motor function will follow the circle without difficulty, and the software will detect a smooth, circular trace (Figure 1A). An abnormal subject will not be able to accurately track the trace - It will show an erratic pattern that will indicate impaired neural skills (Figure 1A). The App will automatically check the database to compare how similar the new pattern is to the baseline pattern. If the software detects an abnormally different pattern, which

would be indicative of a concussion, the subject would be notified to seek immediate medical attention.

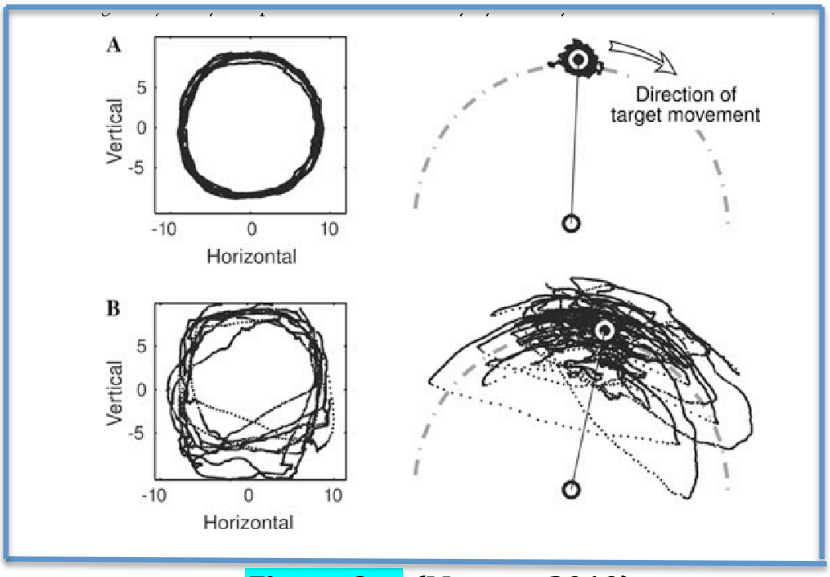

Figure One ***(Maruta, 2010)***

Objective 4*: Database*

The centerpiece of this project is the ability of the client software to link to a server containing a database of all subjects' baseline and injury related data. The database would be accessible from a Smartphone via any internet connection, and the server would handle most of the computational load. This is a unique feature of this system, and will allow data to be shared amongst, coaches, parents and physicians. The ability for any user to be able to review and/or update the database in real time, thus, allowing decisions to be made quickly, and the proper care to be taken immediately. Since the system is internet accessible, decisions can be made in the middle of a game or meet, and coaches can be confident that allowing players to return to the game will not lead to SIS (Second Impact Syndrome).

Procedure

There are many online versions of this type of product already available today. We do not propose to reinvent the wheel, but we feel that the best way to accomplish our goals is to partner with an already established vendor that has a track record of helping schools and athletes avoid SIS cases. One such vendor is ImPACT, which has been producing mTBI assessment products for around 20 years. We would also need to license and develop the Eye Tracker technology from Dr. Jamshid Ghajar of the Brain Trauma Foundation. In order to establish criteria for allowing student athletes back on the field, we would also need to partner with a neurologist who would help establish the concussion testing criteria based upon data transmitted to the database.

It is anticipated that it would take about one year for software engineers to write the Smartphone App and develop the backend database. A server will need to be established with the ability to host the database and compute the likelihood of mTBI. Transferring the Eye Tracker software and video tracking ability to the Smartphone platform will require additional time and testing, but could probably be accomplished in one-and-one half years.

In the first year after launch of this project, we propose including a short evaluation about the efficacy of the product to be completed by end-users. The data gathered would inform us about what users like and dislike and provide an opportunity for suggestions for improvements.

Section V: Available Resources

ImPACT. ImPACT (Immediate Post-Concussion Assessment and Cognitive Testing) is the first validated computerized concussion evaluation system. This type of concussion assessment may help in objectively evaluating the concussed athlete's post-injury condition and track recovery for safe return to play, thus, preventing the cumulative effects of concussion. An athletic trainer, school nurse, athletic director, team coach, team doctor may administer ImPACT, or anyone trained to administer baseline testing. The test battery consists of a number of alternative forms by randomly varying the stimulus array for each administration. This feature was built into the program to minimize "practice effects" that may have limited the usefulness of more traditional neurocognitive tests. ImPACT takes approximately 20 minutes to complete. The program measures multiple aspects of cognitive functioning in athletes. Contact Info: Khurram Sharif 616-254-8586 *www.impacttest.com*

Sportssafety Labs LLC. The Concussion App from SportSafety Labs is a free smartphone-based application. It contains information on how to recognize a concussion using a portable format for use at sporting events. The Concussion App also includes useful emergency functions to call an ambulance via 911, to locate the nearest hospital with driving directions, and to send one's location coordinates via email to emergency and rescue personnel. The Concussion App is designed for serial administration -- the words and symbols in the tests are randomly rearranged from a large bank of potential stimuli each time the test is given, minimizing potential learning effects that may be problematic in other concussion testing systems. A shortcoming of the Concussion App is that one has the option of purchasing a

diagnostic module, which uploads objective tests to evaluate the physiological and neurocognitive status of pre-concussion (baseline) and post-concussion (injured) athletes. Another downfall is that the informational report and its data are stored on one's smartphone, which may be emailed from his smartphone to one's physician to support their diagnostic interpretation of his condition. The Concussion App relates to our grant proposal in which we want to include objective tests that evaluate the person after administrating a baseline pre-concussion test and compares it with the post-concussion results. Contact: Jean Rickerson 360-775-8197. www.sportsconcussions.org.

MedHand International: MedHand International was formed in 2001 by a group of medical doctors and computer engineers. Its mission is to deliver clinical information "at the point of care" for health care professionals. MedHand International's main product is *Dr Companion* which is a full mobile library delivered on a flash memory card which the doctors can freely move between laptops/stationary computers, smartphones an PDA's (Personal Digital Assistant) giving them instant access to their most trusted references all over the world whenever they need them. *Dr. Companion* collaborates with all major publishers in the Medical Life Science sector and has recently a six-year worldwide exclusive agreement with Oxford University Press for mobile delivery of their popular medical handbooks series. MedHand International provides information on any type of computing device running any type of operating system. One downside of this app is that it is only utilized by doctors or professionals and should be mainstreamed to coaches, parents and students. The *Dr. Companion App* correlates with our grant

proposal in which there will be a database linked to a server that saves the patient's pre and post-concussion results and are readily accessible for doctors or professionals. Contact 468-664-4402. support@drcompanion.com, Medhand.com

Concussion Recognition & Response: The Concussion Recognition & Response ™ app is a new tool that helps coaches and parents recognize whether an individual is exhibiting/reporting the signs and symptoms of a suspected concussion. The app allows the user to complete a checklist of possible signs and/or symptoms to determine whether to remove the child from play and the need for further medical examination. The app allows users to record pertinent information regarding a child with a suspected concussion and share periodic information via email with health care professionals; it also provides a system for post-injury follow-up. The cost of the CRR is priced at $3.99 and is only available at the Apple® App Store℠ and the Android Market. In addition to the child's name, age, gender and sport, the location of the injury is tracked by the device's GPS, and its camera can be used to photograph the external injury. Along with the answers to the guided questions, this information can be e-mailed to a health care provider to provide accurate documentation of the child's condition at the time of the injury. The CRR concussion information section helps coaches and parents to make an informed decision regarding how to proceed after a child's injury and consult with concussion specialists while at home and to determine whether a child is capable of returning to the game. One fault of this app is that it allows a person to observe the injury rather than tending to the injured person directly through a series of tests. The concussion

Recognition and Response app is connected to our grant proposal in which the camera can photograph the injury. Contact: Gerard G. Mihalik, 800-331-8378.

Jamshid Ghajar, MD, PhD, Facs. Dr. Ghajar is a neurosurgeon who is deeply involved in brain research and has established a research institute to study brain injury. He was trained at UCLA and Cornel Universities, and has spent a lot of time investigating the effects of mild and severe brain trauma. Dr. Ghajar has been interviewed on CNN and Nova (Nova Science Now!, 2008) and has been instrumental in developing the Eye Tracker mTBI system. Contact: (212)746-2396. jam@ghajar.net

Cimmaron Software, Inc. Cimmaron Software is a custom design company based in Salt Lake City. They specialize in web based client-server applications, and use JAVA programming to complete systems based on customer specifications. In the past, their main customer base has used them to design highly reliable laboratory workflow systems using an Oracle database as the backend. They are used to integrate lab equipment into their tacking systems, and their design guarantees that any data transferred is immediately stored in the database - loss of an Internet connection results in little or no loss of data. This company would be an ideal partner to actually write the Smartphone software, and would also be a source of how to set up the servers and database. Contact: Ron Lindstrom (801)532- 3080 www.cimsoft.com

Brain Trauma Foundation (BTF). BTF is a research institute dedicated to studying the effects of traumatic brain injury (Brain Trauma Foundation, 2011). They have created guidelines for diagnosing and treating mTBI in athletes and for

the military. They have also gathered data on the incidence of mTBI in military personnel during the wars in Afghanistan and Iraq. Researchers at BTF have developed the Eye Tracker system to monitor the effects of mTBI in a clinical setting, and have been miniaturizing the product to make it available onsite at sports venues or on battlefields. Contact: Jamshid Ghajar (212)772-0608 www.braintrauma.org

Section VI: Summary and Evaluation

A 21st century mobile concussion test that takes all available technologies, along with an integrated database, will make student-athletes less vulnerable to long term effects from head trauma. These positive results will be directly related to the need for improved concussion testing along with the desire to give parents, coaches, trainers and student athletes what they deserve.

Improving on existing technology involves research, then taking the best parts of all other competitors and combining them into an integrated, evolved program. Taking tests that are being used on computers by trainers and neurological offices was the first improvement made that no competitor has ever accomplished. These tests include cognitive, motor and memory testing where competitors just ask memory questions. Our application includes eye-tracking testing that will enable users to get a full range of results to acquire an accurate reading. After speaking with Mr. Nathan Swift, an athletic trainer at Chino Hills High School, the most necessary feature our software has included is an integrated database that allows testing results to be accessed by qualified assessors (Swift, 2011, March 14). Prior to our software, any testing results would need to be printed

or emailed when head trauma occurred. This is an ineffective procedure if the trauma happened away from the home school and baseline results could not be accused for the best possible test.

The desired result of our application is to prevent an injured student-athlete to return to play after being misdiagnosed by an unqualified individual. Our software takes ambiguities away from coaches and parents and establishes guidelines in what to do in case a trainer is not present. This clarity of injuries will prevent long-term effects from SIS once athletes are held out contact following trauma. The use of this application to go through the pre-concussion baseline testing will also create awareness of the severity of concussions amongst youth sports.

Evaluating our application on the short-term basis will begin with beta-tests among a few high profile high schools across the United States. These schools will need to have diverse climates so we can see our tests used in any array of different sports prone to causing head trauma. By giving our tests to schools with different climates, we will be able to sample usage with sports ranging from ice hockey to surfing. Imbedded at the end of our testing will be a short evaluation to give immediate feedback to our programmers on glitches or areas of improvement. It will also be beneficial for our evaluation to have a telephone service department for any problems that need immediate attention. In order to pair up with these short-term evaluation methods, we will send representatives to coaches and trainer conventions during the first year of operation. This aspect will enable us to get feedback on how our product is fulfilling the need of our consumers by improving student athlete safety.

Long-term evaluations of the application are where the results we desire will be found. Through statistical research over the duration of our application, we will be able to analyze the change in student-athletes seeking consultation with physicians regarding possible brain trauma. An increase in physicians dealing with mTBI will be directly related to a better understanding of the importance of concussion symptoms. A parallel study would be occurring on long changes in the amount of students suffering from SIS. Our product will be successful when we show that our users have a decreased chance of SIS compared to the rate found at schools that do not use a concussion testing system.

Section VII: Grant Proposal Sources

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