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Puzzling Your Puzzler

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Puzzling Your Puzzler

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ABSTRACT

The following is summarizing a proposed experimental study based on current literature review and research to evaluate a new interventional therapy for the treatment of concussion compared to current therapeutic practices.

Background and Purpose: Concussions have become a major concern in the medical field in recent years. Several research studies have been conducted to learn the signs and symptoms regarding concussions. Recent literature has found that the signs and symptoms of a concussion are similar to those of patients suffering from Alzheimer's disease. Treating Alzheimer's disease has changed in recent years. Research has found that mental rehabilitation, also known as mental gymnastics, has aided in slowing the progression of the disease. Therefore, the purpose of this study is to see that if the treatment for Alzheimer's patients, mental gymnastics, could be used as a form of mental rehabilitation of those suffering from a concussion to improve return to baseline cognitive function.

Methods: The subjects will be obtained through a convenient sample from the local Akron Children's Hospital Sports Medicine Center over a three year span. It will include both male and female patients between the ages of 13 and 18 years old. The inclusion parameters for the study are individuals that are diagnosed with a concussion by a sports medicine physician using a SCAT 2 form and clinical evaluation. The patients will first be examined and tested for a concussion using the SCAT 2 form and reaction time test. Then, the patients are randomly assigned a to the control group, receiving current standard treatment or the experimental group, receiving standard therapy treatment plus a specific mental gymnastics protocol. After a week, the patients will return to the office for a follow- up visit where the packets will be retrieved and patients will again undergo clinical assessment, SCAT 2 assessment, and reaction time assessment to evaluate concussive symptoms. The data collected will then undergo statistical analysis using a two sample t- test.

Keywords: Alzheimer's disease, concussions, SCAT 2, mental rehabilitation, mental gymnastics, reaction time.

DEFINING THE PROBLEM

Research Question

Concussions have become a growing concern in the medical field. A concussion is defined as a complex pathophysiologic process affecting the brain which is induced by traumatic biomechanical forces. The signs and symptoms of a concussion can be short and long term and lead to other complications in mental health (Center for Disease Control, 2015). Currently, the only treatment recommendation for cognitive recovery of a concussion is rest. The signs and symptoms of a concussion are similar to those of Alzheimer’s disease (NIH, 2011). Alzheimer’s disease is a debilitating mental disease that results in a deterioration of the mind due to Apolioprotein 4 deposits (Moser & Schatz, n.d.). These deposits can also be found in the long term effects of a concussion which can result in early onset of Alzheimer’s. Research has found that mental rehabilitation has aided in slowing the progression of Alzheimer’s disease. Therefore, this study examined the applicability of mental rehabilitation used for Alzheimer’s patients in treatment of concussions. The question it specifically aims to address is: Does the use of Alzheimer’s mental rehabilitation exercise when applied to a concussion patient have an effect on the length of time of cognitive impairment?

Experimental Hypothesis

1. There will be a statistically significant decrease in the number of school days missed by concussed patients that receive mental rehabilitation.

Assumptions

1. All subjects will accurately report their symptoms and missed school days.
2. All materials will be returned to the researcher.
3. All materials will be fully filled out and completed.
4. All patients will follow up at the one week period mark.
5. All patients will complete the activities without assistance from outside sources or other individuals.

Delimitations

1. Thirteen to eighteen year old patients presenting to the Sports Medicine center at Akron Children's Hospital.
2. Participants can have no previous or current brain injury diagnosed through radiographic findings (i.e. CT scan with hemorrhage in the brain).
3. The SCAT 2 form will be the only tool used to evaluate cognitive impairment resulting from a concussion.
4. The Reaction time clinical device will be the only tool used to evaluate the severity of the concussion.
5. Word Searches and double puzzles will be the only activities used in the mental rehabilitation technique while otherwise maintaining current clinical treatments for recovery of a concussion.

Operational Definitions

1. SCAT 2 Form-The tool used to aid in diagnosing a concussion along with clinical evaluation.
2. Missed School Day- Any day on the school calendar that the subject does not attend the full school session.
3. Reaction Time clinical device- The tool used to measure reaction time of a subject.
4. ImPACT Normative tables- Tables used to evaluate reaction times to determine the severity of a concussion.
5. Concussion- A complex pathophysiologic process affecting the brain which is induced by traumatic biomechanical forces.

Limitations

In this study, there are a few limitations that could arise as a result of the design. The first element that may cause limitation is the use of minors as subjects as they may not complete all tasks fully or without outside resources. Another element that may cause limitation in the data is the possibility that the subjects may be lost to follow up visit which would result in a loss of data and decrease in sample size. This could skew the results by showing that the treatment is more or less effective than it actually is on cognitive rehabilitation. Also the population may limit the study since it could be skewed due to most sports concussions occurring in high contact sports which usually favor the male gender. The last foreseeable limitation that could arise in the data is in clinician assessments and patient's reporting of symptoms as these are both subjective assessments. This limitation could cause the data to be skewed resulting in type I or type II error in the statistical analysis.

Significance of Study

Researching concussions is very important in the medical field today. With the number of concussions in patients increasing, the knowledge of how to best treat concussions must be further investigated. This study is significant to the medical field because it investigates a new approach to treatment for concussions. Although the brain may need rest after a concussion due to the magnitude of the injury, it also needs to be slowly re-engaged into normal function like any other injury. Therefore, this study could initiate a breakthrough in the treatment of concussions by incorporating a treatment that fully progresses every aspect of the patient's recovery, both mental and physical to normal function after a concussion.

LITERATURE REVIEW

According to the Center for Disease Control and Prevention (CDC), it is estimated that 300,000 sports-related concussions occur each year (Center of Disease Control, 2015). The large quantity of patients suffering from this injury has sparked an increase in research into the topic. The research has included the mechanism of injury, signs and symptoms, epidemiology, diagnostic tools, the return to sport physical rehabilitation, and the future effects on the body. However, a growing concern in the field of sports medicine is the patient's return to education and the patient's ability to be reintegrated back into the school atmosphere following a concussion (McGrath, 2010). Currently, the patient is withheld from school for a day unless a physician prescribes a longer duration. Then, the patient is slowly re-exposed to the learning atmosphere starting with half days and then progressing to full days. This often results in the students falling behind in their classes. Alzheimer's patients suffer from a different disease, but present with similar symptoms to concussions, such as increased sleeping, irritability, memory problems, changes in mood or personality, and slowed reaction time (NIH, 2010). This review will examine current treatment and research into both Alzheimer's disease and concussions to evaluate similarities or differences into both disease processes and evaluate any possible crossover of treatment between Alzheimer's and concussions as a new proposed therapeutic device for mental rehabilitation of concussions.

A concussion is a complex pathophysiologic process affecting the brain which is induced by traumatic biomechanical forces. Concussions occur due to a direct blow to the head, face, neck, or elsewhere on the body that has an impulsive force transmitted to the head (Gessel, Fields, Collins, Dick, & Comstock, 2007). These forces may occur in two ways, linear or rotational. Linear forces are when the brain is propelled in a single direction due to the force that acted on the head. An example of this would be a soccer player falling to the ground and hitting the back of her head. The falling motion propels the brain in a straight downward motion. The results are a coupe and counter coupe type injury to the brain. Rotational forces occur when the brain is sent in a clockwise or counterclockwise motion while also experiencing a linear force. An example of this type of mechanism would be when a football player is tackled, but on his descent to the ground his head strikes another opponent's knee (Signoretti, Lazzarino, Tavazzi, & Vagnozzi, 2011). The fall would cause the linear motion, while the strike from the knee would cause the rotational motion. These forces cause a quick onset of short duration impairment to neurologic function that often is resolved spontaneously but can also result in neuropathological changes (Register-Mihalik et al, 2013).

The clinical symptoms of a concussion can range depending on the severity of the impact and the age of the patient at the time of injury. The clinical symptoms often presenting at the time of injury reflect a more functional disturbance rather than of a structural injury to the brain. The most common symptoms of concussion include headache, sleep disturbances, irritability, changes in personality or mood, memory dysfunction, decrease reaction time, dizziness, and poor attention or concentration (Stewart, Mcqueen-Borden, Bell, Barr, & Juengling, 2012). The larger the injury force on impact the more symptoms develop and the longer the symptoms last. If a concussion persists for months or years, or an athlete receives multiple concussive injuries to the same area of the brain, calcium deposits may form in the injured area of the brain leading to brain deterioration and worsening or permanent symptoms (Lear & Minh-Ha, 2012). One of the persisting effects of a concussion includes second impact syndrome. Second impact syndrome occurs after a patient returns to activity following a concussion and receives a second hit to the head. The second hit causes further damage to the brain that is often times irreversible and can result in death (Kissick & Johnston, 2005).

Age is the other larger component in long term outcomes and risks of concussive injury. Concussions most frequently occur in youth and young adults involved in competitive sports. Males between the ages of fifteen and thirty-four are especially susceptible to concussions due to a higher risk of head to head contact in sports, like football (Clay, Glover, & Lowe, 2012). Female patients are at a higher risk for concussions between the ages of fifteen and twenty-four years of age (Gordon, Dooley, & Wood, 2006). However, recent studies have found that when examining sports where men and women are equal in competition, such as basketball and soccer, women are at a higher risk of obtaining a concussion (Medina McKeon et. al, 2013). Although the patients may heal easier due to their age, they are also more susceptible to long term effects of the concussions and the deadly second impact syndrome. Adults can experience concussions especially during automobile accidents or recreational sports. However, their brains are already fully formed and function at a different capacity than youth and adolescents that are in school. According to the CDC, an estimated 900 sports-related traumatic brain injury deaths occur each year, with over 85% of concussions going undiagnosed (CDC, 2015).

Concussion is a clinical diagnosis after excluding intracranial hemorrhage for traumatic brain injury. Although no one test exists to confirm the diagnosis, the patient can undergo several examinations to aid in diagnosis depending on the individual’s situation. For immediate field evaluation directly after injury clinicians can examine the participant’s ability to return to the current athletic contest, using two tools, the Sports Concussion Assessment Tool and ImPACT test (Melander & Moen, 2014). For most school sports, the student’s are asked to have a physical completed prior to the start of their athletic participation. Recently, schools have begun to have students take baseline examinations on brain function prior to participation in sports, especially contact sports like football, soccer, and basketball. The examination is computerized testing that records the students' memory function, reaction time, and symptoms prior to obtaining a concussion. This test is known as the ImPACT test and is used for the baseline examination, as well as the preliminary examination within 24 to 72 hours after injury (Stewart, Mcqueen-Borden, Bell, Barr, & Juengling, 2012). Another useful test implemented to identify concussions is the SCAT. This test must be done immediately after the athlete is injured. It includes a subjective measure of symptoms, a long and short term memory function assessment and balance testing (Schneider et al, 2013). Unfortunately, this test is only reliable within the first 24 to 48 hours of the injury. If the symptoms of a patient are severe and showing no signs of improvement, then physicians may order additional test that could include Computed Tomography (CT) or Magnetic Resonance Imaging (MRI) to rule out other conditions such as cerebral hemorrhaging. For those who obtain concussions by non- athletic means the SCAT and the ImPACT tests are not available and diagnosis requires trained physician evaluation, such as by the Emergency Department, and they may also undergo CT and MRI imaging to evaluate for cerebral hemorrhaging. The patients would also undergo Balance Error Scoring System test (BESS). This examination would be conducted to evaluate the patient's balance, which is often altered by a concussion (Schneider et al, 2013). These tests can help guide the clinicians in how to best help the patient. It also can help the clinician design a treatment plan based on the patient's symptoms and the severity of his or her injuries.

Clinicians are faced with a very difficult task when trying to design a treatment plan for a patient diagnosed with a concussion. Treatment for concussions involves both mental and physical rehabilitation. The physical rehabilitation is a 6 step protocol that slowly re-engages the patient into activities, while trying to minimize over stressing the patient's brain (Kozlowski, 2014). The first step is no activity and complete cognitive rest. This phase may take days or weeks depending on the severity of the concussion. Once the patient is asymptomatic, then he or she may progress to the next level which is light aerobic activities that include walking or riding a stationary bike and no resistive training. This phase begins with the patient performing activities for a short duration and slowly increasing the time to avoid aggravating the brain and causing the symptoms to return. Next, the patient enters a sports specific or general exercise phase and begins some resistive training if necessary. For non-athlete patients, after this phase the patient is able to slowly return to his or her normal physical function. In athlete specific rehabilitation, the next phase is the non- contact training drills in which the athlete is able to return to practice but is not able to partake in any activities that involve contact with other teammates or opponents. After that phase, the athlete is able to perform full contact practice as long as the athlete obtains medical clearance from a physician. The final step is full competition (Kowlowski, 2014). However, if at any time during the phases the athlete's or patient's symptoms return the athlete is regressed to the previous level. If the symptoms persist at the lower level of activity, then all activity is stopped and the patient returns to the first phase, rest, until seen by a physician. This step by step protocol is designed to slowly progress the patient back into activities to decrease the stress applied to the brain as a result of trying to return to the same level of function prior to injury (McCrory, Meeuwisse, Kutcher, Jordan, & Gardner, 2013). Unfortunately, this rehabilitation process has no set time frames for the patient due to the inability to predict how the brain will heal (Hossler, McAvoy, Rossen, Schoessler, & Thompson, 2014). Physical is again only one part of the rehabilitation process. Mental rehabilitation is another critical and sometimes more challenging component.

Concussions do not only affect the physical body, but also the mental function of the brain. Therefore, the concussion may cause issues with the patient's mental function. This is evident in school age individuals (McGrath, 2010). However, currently the only rehabilitation for the mental function is rest, which requires the patient to miss school. The patient may be withheld from classes for one to two days and then slowly reengaged into the educational routine by starting with half days, and progressing back into full days (Schmies, 2014). However, this can result in several missed days, missed classroom assignments, and missed exams which ultimately leads to an overwhelming amount of make-up work that is due in a very short amount of time. Therefore, this method of rehabilitation for the brain may not be the most beneficial in the long run for the patient because it can cause the patient to regress and have more severe symptoms (Moser & Schatz, n.d.). Currently, this is the only method used in cognitive rehabilitation of a concussive patient with minimal research in this area thus far. Another disease which has similar cognitive symptoms with significant amounts of research published in the area of mental rehabilitation is Alzheimer's disease. In looking at the current literature, could there be practical application crossover in the treatment of the two conditions?

Alzheimer's disease is a progressive neurodegenerative disorder that leads to dementia in later adult life. Alzheimer's disease is caused by a gradual spread of neurofibrillary tangles and amyloid plaques throughout the brain (Hampel, 2012). The process begins several years prior to the exposure of symptoms or problems within the brain function (Yamasaki, Muranaka, Kaseda, Mimori, & Tobimatsu, 2012). Alzheimer's disease causes toxic changes in the brain by abnormal depositions of proteins, specifically Apolipoprotein 4, in the brain that forms amyloid plaques and tau tangles in healthy neurons. This disease causes healthy neurons to work less efficiently by losing their function and an inability to communicate with other neurons until they eventually die (Ashford et al, 2011). Eventually, the neuron death spreads to the hippocampus, which is where memories are formed. In the final stages, the disease causes widespread damage and the tissue in the brain is atrophied significantly.

The effects of the deterioration of the brain tissue occur over time and present slightly differently in each patient. However, there are some common signs and symptoms that most patients present with when they are suffering from the disease (National Institute of Health, NIH, 2011). The signs and symptoms begin with mild signs such as getting lost, changes in personality, memory problems, losing things, and repeating questions. Then, the symptoms progress to more moderate signs such as losing the ability to learn new things, impulsive behavior, increased memory loss, and problems recognizing family and friends. Finally, the severe signs of Alzheimer’s are inability to communicate, increased sleeping, groaning/ grunting, and an inability to recognize oneself or family (NIH, 2011). These signs and symptoms develop progressively over time and become more severe as the disease continues to worsen. As the last stages progress, the patients usually end up bedridden with the disease progression ending in death from failure to thrive.

Alzheimer’s disease primarily affects the older population of patients. It is estimated that over 5 million Americans may have Alzheimer’s disease (NIH, 2011). There are two types of Alzheimer’s disease states depending on age of onset although signs and symptoms are the same. Scientists have found that the early onset disease primarily presents in patients at sixty years of age while late onset presents at age seventy-five or older. The disease presents more often in males versus females and is primarily found in the United States in African American and Hispanic ethnicities. Risk factors for the disease include dyslipidemia, hypertension, obesity, and diabetes. Newer research has also found links between multiple disease states and

Alzheimer's Dementia. These diseases include Down Syndrome, cerebral vascular disease, and traumatic brain injury, particularly concussion. This has heightened concern of the long term affects of concussions in the youth population in regards to increasing risk of Alzheimer's disease due to the increasing amount of youth participation in contact sports and the vast amount of concussions that go undiagnosed and untreated each year. There has been evidence that there is an increased risk of early onset Alzheimer's dementia in those carrying the apoprotein four allele who have experienced a concussion or traumatic brain injury (Moser & Schatz, n.d.). Currently there is no policy on testing for the apoprotein four allele to recognize youth at risk of this association.

There are several diagnostic modalities used to recognize Alzheimer's disease. Currently, there is no gold standard diagnostic test for the diagnosis of Alzheimer's disease. Diagnosis is made through clinical symptoms and an examination using radiographic computerized technologies. The primary sources of the images are Computerized Tomography (CT scan), Magnetic Resonance imaging (MRI), Nuclear Magnetic resonance (NMR), and spectroscopy (Mar, Soto-Gordoa, Arrospide, Morenzo-Izco, & Martinez-Lage, 2015). The CT and MRI examinations can be used identify the damage of protein deposits in the brain's tissue. This can help determine how much of the brain tissue is damaged and how quickly the disease is progressing. In individuals with strong family history and at high risk, the disease can be pre-determined prior to clinical symptom presentation through the use of different biochemical markers (Ashford et al, 2011). The biomechanical markers that can be analyzed include anticholinergic, peptide, cerebral spinal fluid, blood cell, cell dye, medication, and neurotransmitter markers. These markers can determine if certain individuals are predisposed to Alzheimer's or if the individual's symptoms are a result of disease progression. Alzheimer's disease symptoms can also be measured using memory tests and behavioral tests to evaluate brain function and where the damage is occurring (Ashford et al, 2011). However, there are two other forms of examination for Alzheimer’s disease in terms of brain function and progression. These tests include electroencephalography and brain electrical activity. These techniques can be used to determine the neurological functions of the brain. The above tests looking at functionality and progression help the physicians and clinicians determine the best course of treatment to slow the progression of the disease to try to maintain as much function for the individual as possible (Mizrahi & Starkstein, 2007).

The treatment protocol for a patient with Alzheimer’s is specific and individualized per each patient’s disease progression. Research has found several different beneficial rehabilitation techniques for Alzheimer’s that are dependent on the progression of the disease (Anand, Gill, & Mahdi, 2014). Some patients receive medication that is designed to help slow the process while others are challenged through memory games, leisure activities, and exercises (Shan, 2013). Studies have been conducted examining the effects exercise has on the brains function. The results varied, but it was determined that leisure exercise like gardening and walking was beneficial to the brain’s function (Bahar-Fuchs, Clare, & Woods, 2013). One of the more recent techniques found to help maintain the mental function in a patient with Alzheimer’s is mental gymnastics (Verghese et al, 2003). Mental gymnastics are activities that stimulate the brain through puzzles and words. These activities include crossword puzzles, word searches, bingo, and board games (Sobel, 2001). According to research, the decrease in symptoms and the reduction of risk for developing the disease is based on the frequency the patients participate in the activities. It was found that patients that participated in the mental gymnastics four days a week, especially crossword puzzles, had reduced mental function decline by forty-seven percent.

However, this form of treatment is dependent on the stage of progression the patient is currently experiencing (Verghese et al, 2003). The form of treatment is primarily given prior to the presentation of signs and symptoms of Alzheimer's disease, but it can be used in the patients that have already presented with the disease (Verghese et al, 2003). This makes the treatment versatile, but it does not aid the patient once they have reach stage three, complete mental deterioration. Stages one and two of Alzheimer's are where this treatment is most applicable. These stages are very similar in clinical presentation to concussive syndromes. This begs the question; could the treatment of early Alzheimer's be applied to the mental rehabilitation of concussion patients?

Alzheimer's disease and concussions are very complex conditions involving the most important organ in the human body, the brain. These two conditions are similar in their clinical symptoms and presentations as well as the underlying pathophysiology. In terms of symptoms, they both present with sleep disturbances, memory dysfunction, irritability, and mood or personality changes (NIH, 2011). Both diseases cause tissue necrosis and cellular death by cellular deposition with differing deposition deposits. There appears to be a correlation already established between both disease states as traumatic brain injury (TBI) and concussions are noted as risk factors for Alzheimer's disease (NIH, 2011). With these similarities could the mental gymnastics used to heal and slow progression in loss of brain function in Alzheimer's be applied to the mental rehabilitation of concussion? There has been substantial research on increasing strength of synaptic connections by repeated stimulation of neurons. This is the principle applied with mental gymnastics of Alzheimer's patients. The neurons of a concussion patient have been similarly damaged. Therefore, the mental gymnastics treatment of Alzheimer's patients may be beneficial in the mental rehabilitation of concussion patient's rather than just the current rest therapy, bringing about improved short and long term outcomes for patients.

The brain is an intricate organ that holds all the hardware that makes the body run. It is the cognitive musculature. Like the mother board of a computer, if one task is not fully accomplished, then the whole system suffers. This is the affect a concussion has on the brain. A concussion disrupts and damages the normal function of the brain for a short time, but ultimately can lead to long term effects. This is similar to Alzheimer's, however in Alzheimer's the disruption and damage occurs over a long period of time and never recovers (Gordon, Dooley, & Woods, 2006). Current concussion therapy focuses extensively on physical rehabilitation with very little emphasis on cognitive rehabilitation. Fortunately, Alzheimer's has several methods of cognitive treatment with extensive research on cognitive presentation. Concussion patients are often only provided the recommendation of full rest for the mind in order to rehabilitate from the injury. This leads to an increased stress level, increased work load, and missed school days in the youth and young adult patients. The six step return to activity protocol is sufficient for rehabilitating the patient, but not the cognitive aspect of the patient's rehabilitation (Medina McKeon et al, 2013). The patient often returns to school with no progression regarding the work load and often has a large cognitive burden placed on the healing brain. Therefore, the purpose of this study is to see that if the treatment for Alzheimer's patients, mental gymnastics, could be used as a form of mental rehabilitation of those suffering from a concussion to improve return to baseline cognitive function.

METHODS

A double blinded experimental research design will be used to conduct this study. The research will be used to examine if rehabilitating the mind after a concussion will aid in decreasing the number of school days missed by patients. This study is a small pilot study that is being conducted to initiate the investigation into mental rehabilitation for patients that obtain a concussion in sports. The control group will be individuals that receive the standard treatment for a concussion, which includes rest, no electronic devices, and no school or school work if symptoms are severe. The experimental group will be participants that will receive the standard treatment, but are asked to complete a packet of mental activities that are divided into daily assignments to stimulate cognitive rehabilitation. The model for the experimental group treatment will follow a progression technique similar to that used in the 5 step return to play physical rehabilitation protocol. The study will be conducted over a three year span starting in June of 2016 and concluding in June of 2019. The end data collection will be observing the number of school days missed as a result of concussions. A missed school day will be defined as any week day that the student does not attend his or her full normal school session. The study will be approved by the Internal Review Board prior to obtaining participants for the study. Informed Consent will be obtained by all participant's parents or legal guardians, as well as by the participants themselves prior to the initiation of the study.

Subjects

The subjects obtained for this study are a convenient sample from only one hospital. They will be both male and female patients from secondary schools in the surrounding area of Akron Children's Hospital. Participants will be selected from patients seeking medical attention at Akron Children's Hospital Sports Medicine Center between the ages of thirteen and eighteen years old.

The inclusion parameters for the study are individuals that are diagnosed with a concussion by a sports medicine physician using a SCAT 2 form and clinical evaluation. A concussion will be defined by clinical symptoms suggestive of a concussion with a score of 80 or less on the SCAT 2 form. There has been no validation data to suggest an absolute SCAT 2 score that is predictive of concussion so the point evaluation in this study is an arbitrary cutoff based on clinical experience. The exclusion parameters are individuals that are not diagnosed with a concussion by a sports medicine physician in the center at Akron Children's Hospital, are unable to read English, are illiterate, or are symptom free and released to return to normal activities with only one visit to the Sports Medicine Center. Those diagnosed with a concussion in the emergency room or other facilities will not be included in the study if they are not seen by the Sports Medicine Center within one to three days after his or her initial injury. The participant must be able to make a follow-up visit one week after his or her initial visit and diagnosis; otherwise he or she will not be able to partake in the study. Finally, if the individual has a concussion, but also has additional complications such as a hemorrhage within the brain he or she will not be included in the study.

In this study, the clinician and the subject are both blinded to the treatment being distributed. The researcher will randomly assign the subjects a numbered packet using a random number generator, which the clinician performing the evaluations is not aware of the treatment the subject is receiving for the study. Also, the subjects will not know which treatment group they are in since both the control group and experimental group will be receiving numbered packets.

Instruments

Reaction time clinical device will be used in order to test if the subject with a concussion is experiencing a deficit. This tool will be used to determine the severity of the concussion. The reaction times obtained through this procedure will be compared to normative data collected by the ImPACT test to categorize the subjects' data. The normative tables applicable to this study can be found in Appendix C. This tool is used by having the clinician instruct the patient on how to catch the wooden rod. This procedure is as follows: The clinician informs the patient he or she is to catch the stick using their dominant hand (identified as the hand he or she writes with). The stick will be dropped at a random time interval which will initiate the timer. Once it is dropped, the subject is to catch the stick in the dominant hand between the thumb and the index finger. As soon as the subject catches the stick the timer is stopped. The test is conducted eight times with one practice attempt.

Example of the Reaction time clinical device:

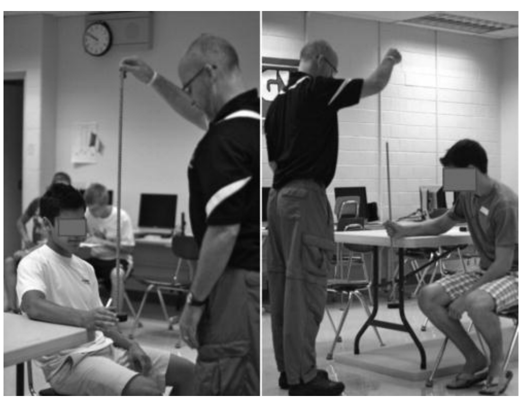

Figure 1. MacDonald, J., Wilson, J., Young, J., Duerson, D., Swisher, G., Collins, C. L., & Meehan III, W. P. (2015). Evaluation of a Simple Test of Reaction Time for Baseline Concussion Testing in a Population of High School Athletes. *Clinical Journal Of Sport Medicine*, *25*(1), 43-48.

Word searches and double puzzles will be used to mentally challenge the subjects. The purpose of the puzzles and word searches are to challenge, but not overwork the brain to help rehabilitate the mind for returning to school. They will be generated using an online puzzle website called Discovery Education (http://www.discoveryeducation.com/free-puzzlemaker/). The website will be accessed on an HP Pavilion Entertainment PC and printed on a HP Inkjet 4400 printer. The puzzles will progressively become more difficult with each day.

Example of the Word Searches and Double Puzzles: See Appendix D and E forms

SCAT 2 forms will be used in office in order to test the mental function of the patient. The SCAT form analyzes the subjects' short term memory, long term memory, balance, and coordination. This will be conducted by a clinician in the office. The clinician will follow the steps and instructions on the SCAT form and collect the necessary data from the subject. This data will be used in order to determine whether a patient has a concussion and if he or she has improved between visits.

Example of the SCAT 2 form: See Appendix A form

Symptom score sheet will be used in office and in the packet to obtain subjective measures of the patients' symptoms and the severity of the symptoms. It will be used in the study to see the progression of the patient's symptoms over the one week span. This will be done in the office on the initial visit by the clinician with the patient answering the question. Then the parents will ask the questions at the completion or cessation of the daily activities recording the date and the score for each question.

Example of the Symptom Score sheet: See Appendix B form

Testing Procedures

Upon arrival for patient's initial visit to the sports center the clinician will perform a history and physical exam, as well as, evaluation using a SCAT 2 form to collect baseline data to determine if the patient has a concussion that fits in the parameters of this study. Next, the clinician will test the patient's reaction time using the reaction time clinical device described previously in this paper. Then the clinician will use the normative tables and the average reaction time measured to see how the patient ranks on the normative table. The normative tables will be used to inform the clinician on the severity of the concussion's cognitive impairments based on the reaction time. Upon being diagnosed with a concussion the patient and his or her parents or legal guardian will be asked to participate in the study that is analyzing the effects of experimental treatment on missed school days as defined above. Upon approval, the clinician will have the parents or legal guardians sign the informed consent form along with the patient participating in the study. The patient will then be randomly assigned by a random number generator on a scientific calculator to either a control group or treatment group and handed the appropriate vanilla envelope by the researcher. The researcher will have 300 pre-made packets that are numbered 1 to 300. The packets that are numbered with an odd integer will indicate the experimental group packets, while the packets with even integers will be the control group packets. The researcher will record the patient's name and number in the binder stored at the office. The binder will hold the entire initial and post SCAT 2 evaluation forms, reaction times testing, and number of school days missed. The pre-made and numbered packets does allow the researcher to know which group the subjects are in, but the researcher will not be able to control the number the generator on the calculator chooses for the subject to eliminate bias. It is also important to note that although the researcher is not blind to subject group assignment, they are not assessing the participants themselves. The researcher will only be collecting and evaluating the data after clinical assessments are concluded and patients are instructed to return to activities by a blinded objective third party clinician.

The experimental groups treatment packet will include standard instructions of cognitive rest as delineated by current medical practice with the exception of instructions to complete specific and controlled mental exercises in the forms of word searches and double puzzles, that are divided out by day with a chart in the front that has the patient keep track of the number of activities he or she completed from the daily set, the time it took him or her to complete, whether he or she attended school, if his or her symptoms were increased or decreased by the activities, if all activities were completed, if not completed why, and how many sessions or sittings it took them to complete the daily activities. The activities will begin at an easy level for day one and progress to a difficult level by day 7. The number of activities to complete each day will also increase by three each day, starting at three and progressing to 21 on day seven. At the end of each day the subject and his or her parents or legal guardian will complete the symptoms score sheet with the subject not seeing the results progression if possible. The subject will also fill out the daily chart to manage his or her progress in the packet. The treatment goal is for the subjects to complete all of the daily activities, but if at any point the subject's symptoms become so severe he or she is unable to complete a day's activity set then he or she will document it on the daily chart and continue on that day when symptoms regress and complete as much of the packet as possible prior to his or her follow up visit.

Example of the Chart:

Day	Number of activities completed	Time it took to complete (mins)	Attended School (Yes or No)	Symptoms increase or decrease?	If not all activities were completed , please state why	How many sessions or sittings did it take to complete activities?
1	/3					
2	/6					
3	/9					
4	/12					
5	/15					
6	/18					
7	/21					

The control group will be given standard informational packets on concussions that have the subject follow normal concussion protocol. These protocols include complete rest with no activities that require increase brain function past rest. The subjects will be instructed to avoid electronics, reading, and other activities that heavily work and challenge the brain.

Finally, the next visit to the office will be after the seventh day of activities. Upon arrival, the researcher will obtain from each participant the packet with the activities, the symptom score sheet, and the daily completion chart. The clinician will perform another history and physical, SCAT 2 evaluation on the patient, and retest his or her reaction time and document this information with the preliminary findings that will be used for analysis at the conclusion of the study. These will be stored in a binder in the office marked preliminary and secondary evaluations by the patient's name. At the end of second visit the clinician will ask the subject how many days of school he or she missed as a result of the concussion and record this number on the questionnaire provided in the binder. All end data will be stored in the binder that was previously mentioned and used at the conclusion of the study for further analysis.

Statistical Analysis

At the conclusion of the study, all of the data will be collected for both the control group and the treatment group. Then, using a two sample t- test the number of school days missed by the control subjects will be compared to the number of school days missed by the treatment subjects. The null hypothesis for the test will be that there is no significant difference in the number of school days missed between the control group and those that received mental rehabilitation. The alternative hypothesis that will be used for the test will be that there is a significant difference in the number of school days missed in that the days of school missed will decrease with the mental rehabilitation of the experimental group. Using a significance level of 0.05 the data will be analyzed to determine if there is a significant difference in the number of school days missed by those that received the mental rehabilitation.

REFERENCES

Verghese, J., Lipton, R., Katz, M., Hall, C., Derby, C., Kuslansky, G., ... Buschke, H. (2003). Leisure Activities And The Risk Of Dementia In The Elderly. *New England Journal of Medicine*, 2508-2516.

Sobel, B. (2001). Bingo Vs. Physical Intervention In Stimulating Short-term Cognition In Alzheimer's Disease Patients. *American Journal of Alzheimer's Disease and Other Dementias*, *16*, 115-120.

Moser, R., & Schatz, P. (n.d.). Enduring effects of concussion in youth athletes. *Archives of Clinical Neuropsychology, 17*(1), 91-100.

Gessel, L., Fields, S., Collins, C., Dick, R., & Comstock, D. (2007). Concussions Among United States High School and Collegiate Athletes. *Journal of Athletic Training, 42*(4), 495-503.

Gordon, K., Dooley, J., & Wood, E. (2006). Descriptive Epidemiology of Concussion. *Pediatric Neurology, 34*(5), 376-378.

Clay, M., Glover, K., & Lowe, D. (2012). Epidemiology of Concussion in Sport: A literature review. *Journal of Chiropractic Medicine, 12*(4), 230-251.

Symptoms, Diagnosis and Treatment. (2010, October 12). *NIH Medline Plus*, 19.

Alzheimer's Disease: Fact Sheet. (2011, July 15). *NIH Medline Plus*, 1-8.

Brain Injury Basics. (2015, February 16). Retrieved March 1, 2015, from

http://www.cdc.gov/headsup/basics/index.html

Hampel, H. (2012). Current insights into the pathophysiology of Alzheimer's disease: Selecting targets for early therapeutic intervention. International Psychogeriatrics, 24(Supp 1), s10-s17. doi:10.1017/S1041610212000579

Yamasaki, T., Muranaka, H., Kaseda, Y., Mimori, Y., & Tobimatsu, S. (2012). Understanding the Pathophysiology of Alzheimer's Disease and Mild Cognitive Impairment: A Mini Review on fMRI and ERP Studies. Neurology Research International, 1-10. doi:10.1155/2012/719056

Ashford, J. W., Rosen, A., Adamson, M., Bayley, P., Sabri, O., Furst, A., & Kuwert, T. (2011). Nuclear Medicine Diagnostic Techniques in the Era of Pathophysiology-Based CSF Biomarkers for Alzheimer's Disease. Journal Of Alzheimer's Disease, 2697-103.

Anand, R., Gill, K. D., & Mahdi, A. A. (2014). Review: Therapeutics of Alzheimer's disease: Past, present and future. Neuropharmacology, 76(Part A), 27-50. doi:10.1016/j.neuropharm.2013.07.004

Mar, J., Soto-Gordoa, M., Arrospide, A., Moreno-Izco, F., & Martínez-Lage, P. (2015). Fitting the epidemiology and neuropathology of the early stages of Alzheimer's disease to prevent dementia. Alzheimer's Research & Therapy, 7(1), 1-18. doi:10.1186/s13195-014-0079-9

Mizrahi, R., & Starkstein, S. (2007). Epidemiology and management of apathy in patients with Alzheimer's disease. Drugs & Aging, 24(7), 547-554.

Shan, Y. (2013). Treatment of Alzheimer's disease. Primary Health Care, 23(6), 32-38.

Bahar-Fuchs, A., Clare, L., & Woods, B. (2013). Cognitive training and cognitive rehabilitation for mild to moderate Alzheimer's disease and vascular dementia. Cochrane Database Of Systematic Reviews, (6),

Hossler, P., McAvoy, K., Rossen, E., Schoessler, S., & Thompson, P. (2014). A Comprehensive Team Approach to Treating Concussions in Student Athletes. Principal's Research Review, 9(3), 1.

Kozlowski, K. (2014). Exercise and Concussion, Part 2: Exercise as a Therapeutic Intervention. International Journal Of Athletic Therapy & Training, 19(2), 28-32. doi:10.1123/ijatt.2014-0007

McGrath, N. (2010). Supporting the student-athlete's return to the classroom after a sport-related concussion. Journal Of Athletic Training (National Athletic Trainers' Association), 45(5), 492-498. doi:10.4085/1062-6050-45.5.492

Melander, J., & Moen, J. C. (2014). It’s Just a Game: Preconcussion Baseline Assessment and Return-to-Play Guidelines for Sports-Related Concussions. Orthopaedic Nursing, 33(6), 323-330. doi:10.1097/NOR.0000000000000102

Kissick, J., & Johnston, K. M. (2005). Return to Play After Concussion: Principles and Practice. Clinical Journal Of Sport Medicine, 15(6), 426-431.

Lear, A. M., & Minh-Ha, H. (2012). Sports, concussion: A return-to-play guide. *Journal Of Family Practice*, *61*(6), 323-328.

Schmies, H. (2014). Putting Our Heads Together: Collaborating for Student Success after Concussion. *JOPERD: The Journal Of Physical Education, Recreation & Dance*, *85*(8), 5. doi:10.1080/07303084.2014.946845

Stewart, G. W., Mcqueen-Borden, E., Bell, R. A., Barr, T., & Juengling, J. (2012). COMPREHENSIVE ASSESSMENT AND MANAGEMENT OF ATHLETES WITH SPORT CONCUSSION. *International Journal Of Sports Physical Therapy*, *7*(4), 433-447.

Schneider, K. J., Iverson, G. L., Emery, C. A., McCrory, P., Herring, S. A., & Meeuwisse, W. H. (2013). The effects of rest and treatment following sport-related concussion: a systematic review of the literature. *British Journal Of Sports Medicine*, *47*(5), 1-5.

Signoretti, S., Lazzarino, G., Tavazzi, B., & Vagnozzi, R. (2011). Epidemiology/pathophysiology: The Pathophysiology of Concussion. *Pm&R*, *3*(Supplement 2), S359-S368. doi:10.1016/j.pmrj.2011.07.018

Medina McKeon, J. M., Livingston, S. C., Reed, A., Hosey, R. G., Black, W. S., & Bush, H. M. (2013). Trends in Concussion Return-to-Play Timelines Among High School Athletes From 2007 Through 2009. *Journal Of Athletic Training (Allen Press)*, *48*(6), 836-843.

Register-Mihalik, J. K., Guskiewicz, K. M., McLeod, T. V., Linnan, L. A., Mueller, F. O., & Marshall, S. W. (2013). Knowledge, Attitude, and Concussion-Reporting Behaviors Among High School Athletes: A Preliminary Study. *Journal Of Athletic Training (Allen Press)*, *48*(5), 645-653.

McCrory, P., Meeuwisse, W. H., Kutcher, J. S., Jordan, B. D., & Gardner, A. (2013). What is the evidence for chronic concussion-related changes in retired athletes: behavioural, pathological and clinical outcomes?. *British Journal Of Sports Medicine*, *47*(5), 1-5.

APPENDIX A

SCAT2

Sport Concussion Assessment Tool 2

Name

Sport/team

Date/time of injury

Date/time of assessment

Age Gender M F

Years of education completed

Examiner

What is the SCAT2?[1]

This tool represents a standardized method of evaluating injured athletes for concussion and can be used in athletes aged from 10 years and older. It supersedes the original SCAT published in 2005[2]. This tool also enables the calculation of the Standardized Assessment of Concussion (SAC)[3,4] score and the Maddocks questions[5] for sideline concussion assessment.

Instructions for using the SCAT2

The SCAT2 is designed for the use of medical and health professionals. Preseason baseline testing with the SCAT2 can be helpful for interpreting post-injury test scores. Words in Italics throughout the SCAT2 are the instructions given to the athlete by the tester.

This tool may be freely copied for distribtion to individuals, teams, groups and organizations.

What is a concussion?

A concussion is a disturbance in brain function caused by a direct or indirect force to the head. It results in a variety of non-specific symptoms (like those listed below) and often does not involve loss of consciousness. Concussion should be suspected in the presence of **any one or more** of the following:

- Symptoms (such as headache), or
- Physical signs (such as unsteadiness), or
- Impaired brain function (e.g. confusion) or
- Abnormal behaviour.

Any athlete with a suspected concussion should be REMOVED FROM PLAY, medically assessed, monitored for deterioration (i.e., should not be left alone) and should not drive a motor vehicle.

Symptom Evaluation

How do you feel?

You should score yourself on the following symptoms, based on how you feel now.

	none	mild		moderate		severe	
Headache	0	1	2	3	4	5	6
"Pressure in head"	0	1	2	3	4	5	6
Neck Pain	0	1	2	3	4	5	6
Nausea or vomiting	0	1	2	3	4	5	6
Dizziness	0	1	2	3	4	5	6
Blurred vision	0	1	2	3	4	5	6
Balance problems	0	1	2	3	4	5	6
Sensitivity to light	0	1	2	3	4	5	6
Sensitivity to noise	0	1	2	3	4	5	6
Feeling slowed down	0	1	2	3	4	5	6
Feeling like "in a fog"	0	1	2	3	4	5	6
"Don't feel right"	0	1	2	3	4	5	6
Difficulty concentrating	0	1	2	3	4	5	6
Difficulty remembering	0	1	2	3	4	5	6
Fatigue or low energy	0	1	2	3	4	5	6
Confusion	0	1	2	3	4	5	6
Drowsiness	0	1	2	3	4	5	6
Trouble falling asleep (if applicable)	0	1	2	3	4	5	6
More emotional	0	1	2	3	4	5	6
Irritability	0	1	2	3	4	5	6
Sadness	0	1	2	3	4	5	6
Nervous or Anxious	0	1	2	3	4	5	6

Total number of symptoms (Maximum possible 22)

Symptom severity score

(Add all scores in table, maximum possible: 22 x 6 = 132)

Do the symptoms get worse with physical activity? Y N

Do the symptoms get worse with mental activity? Y N

Overall rating

If you know the athlete well prior to the injury, how different is the athlete acting compared to his / her usual self? Please circle one response.

no different very different unsure

Cognitive & Physical Evaluation

1 Symptom score (from page 1)

22 **minus** number of symptoms — of 22

2 Physical signs score

Was there loss of consciousness or unresponsiveness?	Y	N
If yes, how long? ______ minutes		
Was there a balance problem/unsteadiness?	Y	N

Physical signs score (1 point for each negative response) — of 2

3 Glasgow coma scale (GCS)

Best eye response (E)	
No eye opening	1
Eye opening in response to pain	2
Eye opening to speech	3
Eyes opening spontaneously	4
Best verbal response (V)	
No verbal response	1
Incomprehensible sounds	2
Inappropriate words	3
Confused	4
Oriented	5
Best motor response (M)	
No motor response	1
Extension to pain	2
Abnormal flexion to pain	3
Flexion/Withdrawal to pain	4
Localizes to pain	5
Obeys commands	6
Glasgow Coma score (E + V + M)	of 15

GCS should be recorded for all athletes in case of subsequent deterioration.

4 Sideline Assessment – Maddocks Score

"I am going to ask you a few questions, please listen carefully and give your best effort."

Modified Maddocks questions (1 point for each correct answer)

At what venue are we at today?	0	1
Which half is it now?	0	1
Who scored last in this match?	0	1
What team did you play last week/game?	0	1
Did your team win the last game?	0	1
Maddocks score	of 5	

Maddocks score is validated for sideline diagnosis of concussion only and is not included in SCAT 2 summary score for serial testing.

5 Cognitive assessment

Standardized Assessment of Concussion (SAC)

Orientation (1 point for each correct answer)

What month is it?	0	1
What is the date today?	0	1
What is the day of the week?	0	1
What year is it?	0	1
What time is it right now? (within 1 hour)	0	1
Orientation score	of 5	

Immediate memory

"I am going to test your memory. I will read you a list of words and when I am done, repeat back as many words as you can remember, in any order."

Trials 2 & 3:

"I am going to repeat the same list again. Repeat back as many words as you can remember in any order, even if you said the word before."

Complete all 3 trials regardless of score on trial 1 & 2. Read the words at a rate of one per second. Score 1 pt. for each correct response. Total score equals sum across all 3 trials. Do not inform the athlete that delayed recall will be tested.

List	Trial 1	Trial 2	Trial 3	Alternative word list		
elbow	0 1	0 1	0 1	candle	baby	finger
apple	0 1	0 1	0 1	paper	monkey	penny
carpet	0 1	0 1	0 1	sugar	perfume	blanket
saddle	0 1	0 1	0 1	sandwich	sunset	lemon
bubble	0 1	0 1	0 1	wagon	iron	insect
Total						

Immediate memory score — of 15

Concentration

Digits Backward:

"I am going to read you a string of numbers and when I am done, you repeat them back to me backwards, in reverse order of how I read them to you. For example, if I say 7-1-9, you would say 9-1-7."

If correct, go to next string length. If incorrect, read trial 2. One point possible for each string length. Stop after incorrect on both trials. The digits should be read at the rate of one per second.

			Alternative digit lists		
4-9-3	0	1	6-2-9	5-2-6	4-1-5
3-8-1-4	0	1	3-2-7-9	1-7-9-5	4-9-6-8
6-2-9-7-1	0	1	1-5-2-8-6	3-8-5-2-7	6-1-8-4-3
7-1-8-4-6-2	0	1	5-3-9-1-4-8	8-3-1-9-6-4	7-2-4-8-5-6

Months in Reverse Order:

"Now tell me the months of the year in reverse order. Start with the last month and go backward. So you'll say December, November ... Go ahead"

1 pt. for entire sequence correct

Dec-Nov-Oct-Sept-Aug-Jul-Jun-May-Apr-Mar-Feb-Jan	0	1
Concentration score	of 5	

[1] This tool has been developed by a group of international experts at the 3rd International Consensus meeting on Concussion in Sport held in Zurich, Switzerland in November 2008. The full details of the conference outcomes and the authors of the tool are published in British Journal of Sports Medicine, 2009, volume 43, supplement 1.
The outcome paper will also be simultaneously co-published in the May 2009 issues of Clinical Journal of Sports Medicine, Physical Medicine & Rehabilitation, Journal of Athletic Training, Journal of Clinical Neuroscience, Journal of Science & Medicine in Sport, Neurosurgery, Scandinavian Journal of Science & Medicine in Sport and the Journal of Clinical Sports Medicine.

[2] McCrory P et al. Summary and agreement statement of the 2nd International Conference on Concussion in Sport, Prague 2004. British Journal of Sports Medicine. 2005; 39: 196-204

[3] McCrea M. Standardized mental status testing of acute concussion. Clinical Journal of Sports Medicine. 2001; 11: 176-181

[4] McCrea M, Randolph C, Kelly J. Standardized Assessment of Concussion: Manual for administration, scoring and interpretation. Waukesha, Wisconsin, USA.

[5] Maddocks, DL; Dicker, GD; Saling, MM. The assessment of orientation following concussion in athletes. Clin J Sport Med. 1995;5(1):32–3

[6] Guskiewicz KM. Assessment of postural stability following sport-related concussion. Current Sports Medicine Reports. 2003; 2: 24-30

6 Balance examination

This balance testing is based on a modified version of the Balance Error Scoring System (BESS)[6]. A stopwatch or watch with a second hand is required for this testing.

Balance testing

"I am now going to test your balance. Please take your shoes off, roll up your pant legs above ankle (if applicable), and remove any ankle taping (if applicable). This test will consist of three twenty second tests with different stances."

(a) Double leg stance:
"The first stance is standing with your feet together with your hands on your hips and with your eyes closed. You should try to maintain stability in that position for 20 seconds. I will be counting the number of times you move out of this position. I will start timing when you are set and have closed your eyes."

(b) Single leg stance:
"If you were to kick a ball, which foot would you use? [This will be the dominant foot] *Now stand on your non-dominant foot. The dominant leg should be held in approximately 30 degrees of hip flexion and 45 degrees of knee flexion. Again, you should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."*

(c) Tandem stance:
*"Now stand heel-to-toe with your **non-dominant foot** in back. Your weight should be evenly distributed across both feet. Again, you should try to maintain stability for 20 seconds with your hands on your hips and your eyes closed. I will be counting the number of times you move out of this position. If you stumble out of this position, open your eyes and return to the start position and continue balancing. I will start timing when you are set and have closed your eyes."*

Balance testing – types of errors

1. Hands lifted off iliac crest
2. Opening eyes
3. Step, stumble, or fall
4. Moving hip into > 30 degrees abduction
5. Lifting forefoot or heel
6. Remaining out of test position > 5 sec

Each of the 20-second trials is scored by counting the errors, or deviations from the proper stance, accumulated by the athlete. The examiner will begin counting errors only after the individual has assumed the proper start position. **The modified BESS is calculated by adding one error point for each error during the three 20-second tests. The maximum total number of errors for any single condition is 10.** If a athlete commits multiple errors simultaneously, only one error is recorded but the athlete should quickly return to the testing position, and counting should resume once subject is set. Subjects that are unable to maintain the testing procedure for a minimum of **five seconds** at the start are assigned the highest possible score, ten, for that testing condition.

Which foot was tested: Left Right
(i.e. which is the **non-dominant** foot)

Condition	Total errors
Double Leg Stance (feet together)	of 10
Single leg stance (non-dominant foot)	of 10
Tandem stance (non-dominant foot at back)	of 10
Balance examination score (30 **minus** total errors)	of 30

7 Coordination examination

Upper limb coordination

Finger-to-nose (FTN) task: *"I am going to test your coordination now. Please sit comfortably on the chair with your eyes open and your arm (either right or left) outstretched (shoulder flexed to 90 degrees and elbow and fingers extended). When I give a start signal, I would like you to perform five successive finger to nose repetitions using your index finger to touch the tip of the nose as quickly and as accurately as possible."*

Which arm was tested: Left Right

Scoring: 5 correct repetitions in < 4 seconds = 1

Note for testers: Athletes fail the test if they do not touch their nose, do not fully extend their elbow or do not perform five repetitions. Failure should be scored as 0.

Coordination score of 1

8 Cognitive assessment

Standardized Assessment of Concussion (SAC)

Delayed recall

"Do you remember that list of words I read a few times earlier? Tell me as many words from the list as you can remember in any order."

Circle each word correctly recalled. Total score equals number of words recalled.

List	Alternative word list		
elbow	candle	baby	finger
apple	paper	monkey	penny
carpet	sugar	perfume	blanket
saddle	sandwich	sunset	lemon
bubble	wagon	iron	insect

Delayed recall score of 5

Overall score

Test domain	Score
Symptom score	of 22
Physical signs score	of 2
Glasgow Coma score (E + V + M)	of 15
Balance examination score	of 30
Coordination score	of 1
Subtotal	**of 70**
Orientation score	of 5
Immediate memory score	of 5
Concentration score	of 15
Delayed recall score	of 5
SAC subtotal	**of 30**
SCAT2 total	**of 100**
Maddocks Score	**of 5**

Definitive normative data for a SCAT2 "cut-off" score is not available at this time and will be developed in prospective studies. Embedded within the SCAT2 is the SAC score that can be utilized separately in concussion management. The scoring system also takes on particular clinical significance during serial assessment where it can be used to document either a decline or an improvement in neurological functioning.

Scoring data from the SCAT2 or SAC should not be used as a stand alone method to diagnose concussion, measure recovery or make decisions about an athlete's readiness to return to competition after concussion.

Athlete Information

Any athlete suspected of having a concussion should be removed from play, and then seek medical evaluation.

Signs to watch for

Problems could arise over the first 24-48 hours. You should not be left alone and must go to a hospital at once if you:

- Have a headache that gets worse
- Are very drowsy or can't be awakened (woken up)
- Can't recognize people or places
- Have repeated vomiting
- Behave unusually or seem confused; are very irritable
- Have seizures (arms and legs jerk uncontrollably)
- Have weak or numb arms or legs
- Are unsteady on your feet; have slurred speech

Remember, it is better to be safe.
Consult your doctor after a suspected concussion.

Return to play

Athletes should not be returned to play the same day of injury. When returning athletes to play, they should follow a stepwise symptom-limited program, with stages of progression. For example:

1. rest until asymptomatic (physical and mental rest)
2. light aerobic exercise (e.g. stationary cycle)
3. sport-specific exercise
4. non-contact training drills (start light resistance training)
5. full contact training after medical clearance
6. return to competition (game play)

There should be approximately 24 hours (or longer) for each stage and the athlete should return to stage 1 if symptoms recur. Resistance training should only be added in the later stages.
Medical clearance should be given before return to play.

Tool		Test domain	Time	Score			
			Date tested				
			Days post injury				
SCAT2		Symptom score					
		Physical signs score					
		Glasgow Coma score (E + V + M)					
		Balance examination score					
		Coordination score					
	SAC	Orientation score					
		Immediate memory score					
		Concentration score					
		Delayed recall score					
		SAC Score					
Total		**SCAT2**					
Symptom severity score (max possible 132)							
Return to play				Y N	Y N	Y N	Y N

Additional comments

Concussion injury advice (To be given to concussed athlete)

This patient has received an injury to the head. A careful medical examination has been carried out and no sign of any serious complications has been found. It is expected that recovery will be rapid, but the patient will need monitoring for a further period by a responsible adult. Your treating physician will provide guidance as to this timeframe.

If you notice any change in behaviour, vomiting, dizziness, worsening headache, double vision or excessive drowsiness, please telephone the clinic or the nearest hospital emergency department immediately.

Other important points:

- **Rest and avoid strenuous activity for at least 24 hours**
- **No alcohol**
- **No sleeping tablets**
- **Use paracetamol or codeine for headache. Do not use aspirin or anti-inflammatory medication**
- **Do not drive until medically cleared**
- **Do not train or play sport until medically cleared**

Clinic phone number

Patient's name

Date/time of injury

Date/time of medical review

Treating physician

Contact details or stamp

APPENDIX B

Concussion Symptom Score Checklist

Athlete Name: Date of Injury:

Rate the severity of each symptom on a scale of 0-6. 0 indicates you are not currently experiencing that symptom.
1 = Mild; 3 = Moderate; 6 = Severe.

Symptom	Date:	Date:	Date:	Date:	Date:	Date:	Date:
Blurred Vision							
Dizziness							
Drowsiness							
Excess Sleep							
Easily Distracted							
Fatigue							
Feel "in a fog"							
Feel "slowed down"							
Headache							
Inappropriate emotions							
Irritability							
Loss of consciousness							
Loss of orientation							
Memory Problems							
Nausea							
Nervousness							
Personality Change							
Poor balance/coordination							
Poor concentration							
Ringing in ears							
Sadness							
Seeing stars							
Sensitivity to Light							
Sensitivity to Noise							
Sleep Disturbance							
Vacant stare/glassy eyed							
Vomiting							

APPENDIX C

Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT)

Normative Data

Version 2.0 Only

2003

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Normative Table 5: Boys Ages 13 – 15 (N = 183)

Percentile Rank	Verbal Memory Composite	Visual Memory Composite	Processing Speed Composite	Reaction Time Composite	Percentile Rank	Verbal Memory Composite	Visual Memory Composite	Processing Speed Composite	Reaction Time Composite
1	62.88	42.68	14.63	0.810	51	88.00	78.00	34.09	0.570
2	64.00	49.40	16.33	0.753	52	88.00	78.00	34.16	0.570
3	67.52	52.52	17.92	0.730	53	88.00	79.00	34.25	0.565
4	69.00	53.36	21.48	0.706	54	88.00	79.00	34.33	0.560
5	70.00	55.20	22.35	0.698	55	88.00	79.00	34.53	0.560
6	71.00	57.00	22.51	0.690	56	88.04	79.04	34.58	0.560
7	71.88	57.88	22.81	0.681	57	89.00	80.00	34.70	0.560
8	72.72	59.00	23.85	0.673	58	89.00	80.00	35.09	0.560
9	73.00	60.00	24.23	0.670	59	89.00	80.00	35.32	0.560
10	73.00	60.40	25.36	0.660	60	89.00	81.00	35.53	0.560
11	74.00	61.00	26.04	0.658	61	89.24	81.00	35.57	0.558
12	74.08	61.16	26.69	0.649	62	90.00	81.00	35.66	0.550
13	75.00	63.00	26.82	0.640	63	90.00	81.00	35.83	0.550
14	76.00	64.00	27.19	0.640	64	90.00	82.00	35.87	0.550
15	76.00	65.00	27.39	0.634	65	90.00	82.00	35.93	0.550
16	76.44	65.00	27.56	0.630	66	91.00	82.44	36.03	0.540
17	77.00	65.28	27.79	0.630	67	91.00	83.00	36.56	0.540
18	77.12	66.00	28.06	0.620	68	91.00	83.00	36.70	0.540
19	78.96	66.00	28.30	0.620	69	91.96	83.00	36.93	0.540
20	79.00	66.80	29.20	0.620	70	92.00	84.00	37.07	0.540
21	79.00	67.00	29.59	0.610	71	92.00	84.00	37.27	0.534
22	79.00	67.00	29.69	0.610	72	92.00	85.00	37.49	0.530
23	79.00	67.00	29.93	0.610	73	92.00	85.32	37.53	0.530
24	80.00	68.00	30.02	0.608	74	92.00	86.00	37.56	0.530
25	80.00	69.00	30.23	0.600	**75**	93.00	86.00	37.78	0.530
26	80.00	69.00	30.28	0.600	76	93.00	88.00	37.98	0.520
27	80.00	69.00	30.34	0.600	77	93.00	88.00	38.12	0.520
28	80.00	69.00	30.43	0.600	78	93.00	88.00	38.81	0.520
29	81.00	69.00	30.57	0.600	79	93.00	88.00	39.13	0.520
30	81.00	69.00	30.63	0.600	80	93.20	88.20	39.42	0.518
31	81.00	70.00	30.70	0.590	81	94.00	89.00	39.60	0.510
32	81.88	70.88	30.79	0.590	82	94.00	89.00	40.27	0.510
33	82.00	71.00	31.48	0.590	83	94.00	90.00	40.39	0.510
34	82.00	71.56	31.80	0.590	84	95.00	90.56	40.58	0.504
35	82.00	72.00	31.93	0.590	85	96.00	91.00	40.69	0.500
36	83.00	72.24	32.13	0.590	86	96.00	91.24	40.99	0.500
37	83.00	73.00	32.33	0.590	87	96.00	92.00	41.88	0.500
38	83.00	73.00	32.53	0.590	88	96.00	92.00	42.53	0.500
39	84.00	73.00	32.57	0.582	89	96.00	92.00	43.49	0.492
40	84.00	73.00	32.63	0.580	90	96.00	92.60	44.21	0.490
41	85.00	73.00	32.74	0.580	**91**	96.44	94.00	44.52	0.480
42	85.00	74.00	33.01	0.580	92	97.28	94.00	44.81	0.480
43	85.00	74.00	33.27	0.580	93	98.12	94.12	45.21	0.479
44	85.00	74.00	33.43	0.580	94	99.00	95.96	45.42	0.470
45	85.00	74.80	33.47	0.570	95	99.00	96.00	46.42	0.470
46	86.00	75.64	33.57	0.570	96	99.00	96.64	46.98	0.464
47	86.48	76.00	33.64	0.570	**97**	99.00	97.00	50.19	0.445
48	87.00	77.00	33.70	0.570	98	100.00	98.00	51.93	0.437
49	87.00	77.16	33.73	0.570	99	100.00	98.16	52.55	0.355
50	87.00	78.00	33.95	0.570					

Normative Table 8: High School Boys Ages 16 – 18 (N = 158)

Percentile Rank	Verbal Memory Composite	Visual Memory Composite	Processing Speed Composite	Reaction Time Composite	Percentile Rank	Verbal Memory Composite	Visual Memory Composite	Processing Speed Composite	Reaction Time Composite
1	65.36	47.36	19.18	0.764	51	86.00	79.00	37.91	0.530
2	68.18	51.36	26.47	0.738	52	86.00	79.68	38.10	0.530
3	69.00	53.00	26.71	0.730	53	86.00	80.00	38.31	0.530
4	71.00	56.00	27.24	0.696	54	86.86	80.86	38.51	0.530
5	71.00	56.95	27.60	0.690	55	87.00	81.00	38.73	0.526
6	72.54	58.00	27.84	0.674	56	88.00	81.00	38.88	0.520
7	74.00	58.13	28.06	0.650	57	88.00	81.63	38.91	0.520
8	74.00	59.00	28.52	0.643	58	88.00	82.00	39.01	0.520
9	75.00	60.00	29.57	0.640	59	88.81	82.00	39.18	0.520
10	75.00	60.00	29.65	0.640	60	89.00	82.00	39.28	0.520
11	75.49	63.00	30.01	0.630	61	89.99	82.99	39.35	0.520
12	76.00	65.08	30.25	0.630	62	90.00	83.00	39.42	0.510
13	76.00	66.00	30.61	0.630	63	90.00	83.00	39.51	0.510
14	76.00	66.00	31.57	0.627	64	90.76	83.00	39.62	0.510
15	76.00	66.00	31.80	0.620	65	91.00	84.00	40.13	0.510
16	77.00	66.00	31.84	0.620	66	91.00	84.00	40.24	0.510
17	77.03	67.03	32.06	0.610	67	91.00	84.00	40.45	0.505
18	78.00	68.00	32.41	0.610	68	91.00	84.12	40.75	0.500
19	78.00	68.00	32.51	0.610	69	91.00	85.00	40.85	0.500
20	78.80	68.00	32.63	0.610	70	91.00	85.30	41.04	0.500
21	79.00	69.00	32.85	0.606	71	91.00	87.78	41.42	0.500
22	79.00	69.00	32.93	0.600	72	92.00	88.00	41.84	0.500
23	79.00	69.57	33.23	0.594	73	92.00	88.00	42.11	0.499
24	79.00	70.00	33.41	0.590	74	92.00	88.00	42.31	0.490
25	79.75	70.00	33.69	0.583	**75**	92.25	89.00	42.58	0.490
26	80.00	70.34	33.85	0.580	76	93.00	89.00	42.60	0.490
27	80.00	71.00	33.99	0.580	77	93.00	89.00	42.72	0.490
28	81.00	71.52	34.32	0.575	78	94.00	89.00	43.20	0.490
29	81.00	72.11	34.51	0.570	79	94.00	89.61	43.23	0.490
30	81.70	73.00	34.59	0.570	80	94.00	90.00	43.56	0.490
31	82.00	73.00	34.87	0.570	81	94.79	90.00	43.68	0.490
32	82.00	73.00	35.21	0.570	82	95.38	91.00	44.40	0.486
33	82.00	74.00	35.41	0.560	83	96.00	91.97	44.65	0.480
34	82.06	74.06	35.48	0.560	84	96.00	92.00	45.12	0.480
35	83.00	75.00	35.51	0.560	85	96.00	92.00	45.61	0.480
36	83.00	76.00	35.84	0.560	86	96.00	92.00	46.10	0.480
37	83.00	76.00	36.03	0.560	87	97.00	93.00	46.72	0.470
38	84.00	76.00	36.06	0.556	88	97.00	93.00	46.95	0.470
39	84.00	77.00	36.10	0.550	89	97.51	93.00	47.23	0.470
40	84.00	77.00	36.28	0.550	90	98.10	93.00	47.46	0.469
41	84.00	77.19	36.48	0.550	**91**	99.00	93.69	47.79	0.460
42	84.00	78.00	36.54	0.550	92	99.00	94.28	48.23	0.460
43	84.37	78.00	36.65	0.550	93	99.00	95.00	48.88	0.460
44	85.00	78.00	36.87	0.550	94	99.00	95.46	49.31	0.455
45	85.00	78.00	37.10	0.550	95	100.00	96.00	50.21	0.450
46	85.00	78.14	37.24	0.540	96	100.00	96.00	50.60	0.444
47	85.00	79.00	37.34	0.540	**97**	100.00	97.00	50.75	0.435
48	85.00	79.00	37.44	0.540	98	100.00	97.00	51.21	0.420
49	85.91	79.00	37.55	0.540	99	100.00	97.41	51.59	0.359
50	86.00	79.00	37.78	0.530					

Normative Table 11: Girls Ages 14 – 18 (N = 83)

Percentile Rank	Verbal Memory Composite	Visual Memory Composite	Processing Speed Composite	Reaction Time Composite	Percentile Rank	Verbal Memory Composite	Visual Memory Composite	Processing Speed Composite	Reaction Time Composite
1	58.00	43.00	14.13	0.790	51	90.00	79.00	38.79	0.540
2	61.40	49.80	15.91	0.770	52	90.00	79.00	39.02	0.540
3	68.72	53.52	19.05	0.739	53	90.00	79.00	39.17	0.540
4	74.72	54.00	21.49	0.713	54	90.36	79.00	39.32	0.540
5	76.00	54.40	22.74	0.698	55	91.00	79.20	39.53	0.540
6	76.04	56.12	25.53	0.690	56	91.04	80.00	39.55	0.540
7	76.88	58.64	26.67	0.690	57	91.88	80.00	39.62	0.540
8	77.00	59.00	27.85	0.683	58	92.00	80.00	39.72	0.540
9	77.56	59.00	28.83	0.669	59	92.00	80.56	39.81	0.534
10	78.40	59.80	29.28	0.656	60	92.00	81.00	40.09	0.530
11	79.24	61.00	29.28	0.650	61	92.00	81.24	40.48	0.530
12	80.00	61.00	29.32	0.648	62	92.00	82.08	40.58	0.529
13	80.00	61.00	29.48	0.632	63	92.00	82.92	40.58	0.521
14	80.76	62.52	29.88	0.630	64	92.00	83.76	40.71	0.520
15	81.60	63.00	30.09	0.630	65	92.00	84.00	40.75	0.520
16	82.00	63.44	30.27	0.626	66	92.00	84.44	40.77	0.520
17	82.00	64.00	30.44	0.620	67	92.28	85.00	40.81	0.520
18	82.00	64.24	30.52	0.620	68	93.00	85.00	40.88	0.520
19	82.00	65.92	30.84	0.620	69	93.00	85.00	41.07	0.520
20	82.00	66.80	30.93	0.612	70	93.00	85.80	41.32	0.512
21	82.64	67.64	31.91	0.610	71	93.00	86.00	41.64	0.510
22	83.00	68.00	32.50	0.610	72	93.00	86.96	42.01	0.510
23	83.00	68.32	32.56	0.607	73	93.00	88.00	42.26	0.507
24	83.16	69.16	32.69	0.600	74	93.16	88.00	42.29	0.500
25	84.00	70.00	33.28	0.600	**75**	94.00	88.00	42.33	0.500
26	84.00	70.00	33.41	0.600	76	94.00	88.84	42.37	0.500
27	84.00	70.68	33.51	0.593	77	94.00	89.00	42.67	0.500
28	84.52	71.00	33.77	0.590	78	95.04	89.00	43.01	0.495
29	85.00	71.00	34.00	0.590	79	96.00	89.00	43.47	0.490
30	85.00	71.20	34.03	0.588	80	96.00	89.20	44.00	0.490
31	85.00	72.04	34.04	0.580	81	96.00	90.00	44.20	0.490
32	85.00	72.88	34.36	0.580	82	96.00	90.00	44.29	0.490
33	85.72	73.00	34.67	0.573	83	96.00	90.00	44.48	0.490
34	86.56	73.00	34.78	0.570	84	96.56	90.56	45.24	0.490
35	87.40	73.40	34.89	0.566	85	97.00	91.00	46.06	0.490
36	88.00	74.00	35.16	0.560	86	97.24	91.00	46.53	0.490
37	88.00	74.00	35.50	0.560	87	98.00	91.08	46.71	0.489
38	88.00	74.00	35.53	0.560	88	98.00	91.92	46.77	0.481
39	88.00	74.76	35.76	0.560	89	98.76	92.00	46.80	0.480
40	88.00	75.00	35.87	0.560	90	99.00	92.60	47.00	0.480
41	88.00	75.00	36.24	0.556	**91**	99.00	93.00	47.31	0.480
42	88.00	75.28	36.69	0.550	92	99.28	93.56	47.91	0.480
43	88.00	76.00	36.78	0.550	93	100.00	95.00	48.88	0.479
44	88.00	76.00	37.13	0.550	94	100.00	95.00	49.23	0.470
45	88.00	76.80	37.17	0.550	95	100.00	95.00	50.61	0.462
46	88.64	77.00	37.37	0.544	96	100.00	96.28	50.95	0.460
47	89.48	77.00	37.72	0.540	**97**	100.00	97.96	51.12	0.446
48	90.00	77.00	38.18	0.540	98	100.00	99.32	51.89	0.385
49	90.00	77.32	38.62	0.540	99	100.00	100.00	53.15	0.290
50	90.00	79.00	38.73	0.540					

APPENDIX D

Day 1: Riding the Waves

H	S	I	F	R	A	T	S	E	A
M	K	Q	S	E	S	I	I	Z	W
S	H	A	C	L	Y	P	Z	E	B
E	N	Y	L	O	C	K	J	E	O
D	L	E	V	P	R	C	R	R	P
A	H	T	O	C	E	A	N	B	S
S	Q	V	R	C	X	G	L	U	U
H	S	I	F	U	J	D	V	F	R
R	U	E	O	W	T	P	W	L	F
O	T	C	Y	U	B	G	I	B	F

Words:

BREEZE CORAL FISH OCEAN SAND
SHELLS STARFISH SURF TURTLE

APPENDIX E

Day 1: Ocean Floor

ORACL			6					
FSHI	9							
WEASEED		7			8			
LUTETR			3					
TIHASSFR			4					
HELSLS				5				
SFLOSI		2						
RACHON			1					

1	2	3	4	5		6	7	8	9

Unscramble each of the clue words.
Copy the letters in the numbered cells to other cells with the same number.