Examining the use of a Biofeedback Intervention with Athletes Post Concussion

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A thesis submitted to the Faculty of Graduate Studies of

The University of Manitoba

In partial fulfillment of the requirements of Master of Arts

Kinesiology and Recreation Management & Health, Leisure, and

Human Performance Research Institute

University of Manitoba

Winnipeg, Manitoba

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Abstract

This study analyzed the impact of a biofeedback intervention with athletes in sport, specifically those returning to play from a concussion. Although return to play protocols address the physical symptoms related to concussion (i.e., a mild traumatic brain injury), psychological issues related to the injury are often not addressed. Biofeedback is the use of technical equipment to assist an individual to understand physiology through immediate feedback of an action or stimulus and has been found to assist athletes with focus and concentration. In this study, a total of six athletes were recruited to complete a 12-week biofeedback (i.e., breathing) intervention. In addition to physiological markers, focus groups were also used before and after the intervention. The results point to the positive impact of the intervention, particularly the qualitative component. Participants expressed improvements related to anxiety, fear, anger, and relationships with family and friends. Limitations and future directions are discussed.

Acknowledgements

The completion of this thesis would not have been possible without the support, guidance, and multiple re-writes provided by an amazing group of people. First, I would like to thank Dr. Leisha Strachan for her unwavering patience and positivity throughout this entire process. I know it is not easy to deal with my many endeavors, inability to hand things in on time and complete lack of editing skills, but you made the research project one of the best experiences of my life. I truly appreciate everything that you have done for me over the past three years. Your endless support, guidance and motivation were essential in my completion of this thesis and I'm extremely proud and fortunate to be one of your grad students. I would also like to thank my committee members, Dr. Stephen Cornish, Dr. Adrienne Leslie-Toogood, and Dr. Colin Kazina for their time and advice. Your guidance, during the beginning stages of this project, was invaluable and helped develop a basic idea into a full-fledged research project. I would like to thank all the participants who gave their time over three months; you truly made the project.

A huge thank you to my mother Bonnie for her never-ending love, support and encouragement, my father Michael for showing me that it is possible for the human body and brain to recover (so proud of you dad), my sister Katie for being the rock of our family - you are one of my heroes, my sister Emily for always having my back, my sister Heather who makes me appreciate life to the fullest, my aunt Gerry who taught me how to laugh with people not at people, I miss you everyday, my cousin Daniel for inspiring me to go after my dreams, Steve for showing me the greatest gift is providing opportunities for people less fortunate, my god father John for being authentic everyday, my uncle Peter for his mentorship, and my dog Duke for being my best friend. I have to give a massive thank you to the most important two people in my

life, my wife Sarah and son Cohen. Without the two of you believing in me, I would never be here today. The two of you inspire me everyday and bring me so much happiness. I am so fortunate to have the two of you in my life; I truly won the family lottery.

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Chapter 1 : Introduction

Concussions, mild traumatic brain injuries that can occur after a blow that causes a sudden jarring of the head (Broglio et al., 2011), have been making headlines in recent years following high-profile cases among professional athletes and class-action lawsuits brought by former players against the National Football League and the National Hockey League. The issue was further thrust into the spotlight last December with the release of the movie Concussion, starring Will Smith as a physician who discovers the damage that repetitive and untreated concussions had on the brains of former NFL players. In the movie *Concussion* (Landesman, 2015), Dr Bennet Omalu says, “A concussion(s) chokes the brain! And turns people into something else that is unrecognizable of their former selves. ”Over the past decade, there are few topics in medicine and sport that have generated as much public interest as sports-related concussions. A concussion is an injury that can change the way an individual functions physically, cognitively and behaviorally. This research focuses on the emotional and psychological aspects a sport related concussion may have on an athlete’s response to the injury and response to recovery. The last five years, in particular, have seen an increased awareness and understanding develop (Centre Disease Control & Prevention, 2013). All concussions involve a degree of injury to the brain (Broglio et al., 2011). With this newfound knowledge, it is now understood that athletes suspected of having a concussion during play should be removed. This is in order to undergo further evaluation by a trained medical professional. Treated properly, 85 per cent of concussions resolve themselves (Centre Disease Control & Prevention, 2013). Research suggests, however, that someone who fails to get a concussion treated by a trained medical doctor is three times more likely to sustain a second concussion, while

someone who experiences two concussions is nine times more likely to sustain a third. Research also suggests concussions, left untreated, have potential long-term effects, including an increased risk of suicide attempts, higher rates of harmful behaviour, and links to anxiety and depression (Bonfield, Wecht & Lunsford, 2014). The injury should not be brushed off as harmless to an individual's health (Centre Disease Control & Prevention, 2013; Halstead & Walter, 2010). Unfortunately, with the increased attention associated with concussion in medicine and sport, confusion and controversy do persist in many areas of the scientific community and medical communities. These areas of debate and confusion include; the severity of the concussion, how multiple concussions affect the vulnerability of athletes at risk of sustaining future injury, when it is safe for a player to return to sport, and the effectiveness of protective equipment along with other interventions in reducing the incidence and severity of concussive injuries (Wilde et al., 2012).

The intense media coverage on the potential seriousness of sports-related concussions has begun to penetrate our households, communities, workplaces and schools. Dr. Omalu states that should 10% of mothers in the United States begin to perceive contact sports as dangerous to the head, it would be the end of contact sports in 20 years (Landesman, 2015). Concussions are receiving greater attention. There are campaigns to educate athletes, parents, trainers and coaches on recognition and management of concussions. This is pivotal moving forward for the longevity of these contact sports. What is happening now is the withdrawal of contact in youth sports and rule changes designed to reduce the risk of head injury. This has begun to be implemented by major youth sport organizations and is positive and necessary for the health and safety of the youth participating (Buzzini, 2006).

Education of signs and symptoms and the enactment of legislation designed to

protect young athletes suspected of having a concussion has started to create positive awareness around the injury (McCrory et al., 2012). However, research has indicated that there is a long way to go in educating youth athletes, parents, trainers and coaches about concussions to fully understand the risk associated with the injury (McCrory et al., 2012). Sustaining a second concussion while still not fully recovered from a prior concussion may have profound long-term effects on cognitive functioning and behavioral control (Broglio, 2007). Furthermore, consistent and accurate procedures for diagnoses and rehabilitation must improve so that the recovery from a concussion will improve (Bonfield, Wecht & Lunsford, 2014).

Research has demonstrated there is simply too much inconsistency with current standards of concussion management and non-reporting of the injury. A recent 2013 study revealed that high school football players were informed and somewhat knowledgeable about the symptoms and risks associated with concussions. However, the majority believed it was acceptable to continue play with a concussion, especially when it meant winning the game (Anderson, Pomerantz, Mann & Gittelman, 2013). It is critical that the stigma surrounding non-reporting of sports-related concussions in youth is eliminated. Unfortunately, non-reporting of concussion has been suggested to cause potentially long term impairments or fatalities due to reinjuring the brain when still experiencing a concussion.

Ultimately, parents are now faced with determining which sports are safe for their children to participate in including hockey in Canada, football in United States. The education of parents surrounding equipment has started increasing to ensure proper protection for their child's head. If a child does receive a concussion, parents want to know if it will be safe for their child to return to play or not (Podlog, Lochbaum, & Stevens, 2010). These decisions cannot be taken lightly. A child could potentially

sustain long term damage from sustaining a concussion during the stages of adolescent brain development (Broglio et al., 2011).

Rehabilitation of psychological symptoms that hinder youth athletes returning to the specified sport following a concussion is often an arduous challenge. This is due to the complexity of the developing brain and that every concussion reacts differently to each individual (Broglio et al., 2011). The main psychological impacts for concussions become limiting when athletes experience symptoms lasting longer than three months. Another main factor is no two concussions manifest the same way in terms of signs and symptoms making diagnosing and recovery protocols very challenging (Podlog, Lochbaum, & Stevens, 2010). When this takes place, it is known as post-concussion syndrome.

For the purpose of the research, biofeedback will be used as the treatment tool to overcome the psychological setbacks that occur because of post-concussion syndrome. Biofeedback is a technique that can be used for individual's to learn to control the body's physiology, such as muscle tension, skin conductance, respiration rate, temperature and heart rate. With biofeedback, a person is connected to electrical sensors that help receive information or feedback about the body's responses (i.e., bio). The positive or negative feedback helps a person focus on making subtle changes in the body and brain, such as relaxing certain muscles, setting an optimal respiration rate or improving concentration (Johnston et al., 2010). In essence, biofeedback gives an individual the power to use thoughts to control body and brain functioning, often to help with a health condition, physical performance and psychological challenges. The potential of biofeedback to aid with psychological recovery after sustaining a concussion through simulated stress testing to provide a physiological baseline followed by respiration training has never been explored.

There are several theories that have examined the anxiety-performance relationship. For the purpose of the research, there are three main theories of focus. Three sport anxiety theories are namely theory of momentum, multi-dimensional anxiety theory and catastrophe model (Zeeman, 1979). These theories assist in understanding what the athletes may be experiencing returning from a concussion. When specifically looking at catastrophe theory, the butterfly model provides a solid foundation to build from. This mixed methods study will seek to provide insight into the use of focus groups and biofeedback as a viable option to increase confidence and decrease anxiety of athletes who have sustained a concussion. The implication could prove to be positive with assisting youth athletes return to everyday activities. It could help them to avoid being held back from sport participation, social participation, and school sport activities.

The purpose of the research was to eliminate the silence and invisibility of the concussion injury that may be responsible for psychological setbacks when returning to sport. The research shows the potential to achieve the elimination of fear, loss of confidence, poor emotional control, and inability to hold focus and concentrate. The results suggest positive outcomes as the participants expressed positive feedback during the post focus groups. This indicated that the biofeedback intervention provided a possible outlet for athletes to overcome psychological setbacks from sustaining a concussion.

The implication of the research moving forward is positive. The return to play protocol should have psychological recovery as a component in the future. Without the psychological component in the return to play protocol, it may cause limitations to the individual's recovery. If the athlete is psychologically healthy and has the correct tools to manage physical symptoms, then recovery from a concussion may not be so

profound. It may not be a challenge for the individuals who experience long-term effects. An applied multidisciplinary approach to concussion recovery is crucial in being able to address the prolonged psychological factors. Incorporating a multidisciplinary approach to recovery that is managed by a medical doctor who is specializing in concussions recovery to overcome the physical, cognitive and behavioral symptoms.

The literature review has provided research that could potentially aid with psychological recovery, after sustaining a concussion, through a twelve-week biofeedback intervention. I will extensively explore the use of biofeedback as a mechanism to assist with psychological recovery due to experiencing a concussion.

Chapter 2 : Literature Review

The following literature review will give an overview of research relating to concussions, anxiety theories and disorders, emotional control, confidence and biofeedback. Each area plays a key role in the development of the current study. My literature review search consisted of traditional academic resources and online databases. This included the University of Manitoba Library, Google Scholar, PsychINFO, PubMed and Scopus. Every effort was made to include the most recent research. Although there was adequate literature pertaining to concussions, there was confusion surrounding the definition, diagnosis and treatment of the injury. Further, there was limited research examining the younger age categories who have endured a concussions (i.e. 5 to 16 years of age) (Vargas, Channer, Dodick and Demaerschalk. 2012). Reviewing biofeedback technology as a treatment technique, which included training to improve physical and mental health by using signals from the body through rehabilitation and/or retraining new neurological pathways, has led to positive conclusions. Due to the limitation of literature regarding youth concussions and biofeedback in the context of concussion rehabilitation, literature related to biofeedback rehabilitation for stress and anxiety was reviewed.

Concussion

According to Wilde et al. (2012), 80% of concussed athletes will recover within one to two weeks. A concussion is the most complicated injury to the most complicated organ of the body (Wilde et al., 2012). There are three ways a concussion can occur: 1) a stationary hit with a forceful blow (i.e., impact or compressive force), 2) a moving head hits a non-moving object (i.e., acceleration or tensile force), or 3) the head is struck parallel to its surface (shearing or rotational force) (Echemendia, Ruben &

Julian, 2001). The brain is a member of the central nervous system that is responsible for a person's behavior, emotions, thoughts and experiences (Thompson & Thompson, 2006). In addition, it is also responsible for controlling body temperature, blood pressure, heart rate, breathing, communication of information and physical coordination. This means a concussion is a brain injury that can also affect physiological functioning (Thompson & Thompson, 2006). This complexity of the injury makes it unlike any other simply due to the fact that no two concussions have the same injury or recovery protocol (Vargas, Channer, Dodick & Demaerschalk, 2012).

Therefore, recovery from a concussion is very difficult because it could show signs and symptoms that fall into three main categories: physical, cognitive and behavioral. These changes have the ability to alter an individuals physiological and psychological functioning (Covassin, 2008). It is important to note that the developing brain can take longer to recover from an injury (Bloom, 2008). The main issue with psychological setbacks is that they may not be detected until months after and not taken as seriously as the initial physical symptoms (Covassin, 2008).

Definition of Concussion

Concussion is an injury to the mind that involves a multitude of interrelated diagnostic, management, referral and preventive processes and roles (Collins, Kontos, & Russo, 2004). This definition is essential because a concussion does not have a hard diagnosis so by using the technologies and tools available, doctors can eliminate other possible injuries that may be diagnosed. To understand the psychological impacts of a concussion, it is best to begin by understanding what a concussion is. There is adequate literature pertaining to concussions, however, there are many confusing ideas

surrounding the definitions, diagnosis and treatment of the injury. Furthermore, there is limited research that examines the younger age categories that have experienced concussions after extensively research scholarly publications (i.e., five to 21 years of age; Vargas, Channer, Dodick & Demaerschalk, 2012). Studying this demographic is essential due to the highly risk of injury to the brain because the brain is still in the developing stages.

A concussion is considered a mild traumatic brain injury that can affect how the brain normally functions (Bloom, 2008). Another definition states that a concussion is a "brain injury caused by acceleration forces that are a result of either a direct impact to the head, face, or neck or an indirect impact causing an impulsive force to the brain" as defined by Blume & Hawash (2012). This means the brain either moves forward and then back or vice versa penetrating the cerebral fluid causing bruising to that area of the brain contacting the skull. Cerebral concussion (referred to as concussion in this document) often results in functional, not structural damage (Bonfield, Wecht & Lunsford, 2014). It is estimated that between 1.6 and 3.8 million sports-related brain injuries occur each year. Approximately 1.5 million of these are estimated to be concussions (Bonfield, Wecht & Lunsford, 2014).

Although initial symptoms of a concussion sustained through sport participation may seem mild, these symptoms can lead to severe problems in the future (Bonfield et al., 2014). Mild traumatic brain injuries may affect a person's physical, cognitive, and behavioral aspects of life. There are many detrimental effects that may occur after sustaining a concussion. In retired athletes who participated in contact sports, serious cognitive issues can begin to surface such as memory loss, dementia, anger issues and depression (De Beaumount et al., 2009). Longer recovery times of verbal memory and reaction time are being noticed in college athletes with a previous

history of concussions (Makdissi et al., 2013). Any athlete can be at risk for Second Impact Syndrome, which causes rapid swelling of the brain resulting in brain damage or death due to a second concussion. Second Impact Syndrome occurs when an individual sustains a second concussion before the first concussion has fully resolved (Zaichkowsky & Fuchs, 1988). Youth athletes must be protected from these dangerous risks by improving prevention, recognition and management of concussions.

Since medical professionals (i.e., physicians and athletic trainers) are rarely present at youth sporting events, the responsibility falls on the parents and coaches to keep athletes safe. To do this, parents and coaches of athletes must be properly educated about concussion prevention, recognition and management. This is very challenging because there are many mechanisms that can cause a concussion (McCrea, 2005). The main reason concussions are so difficult to recognize is because a concussion presents itself with different signs and symptoms. Essentially, no two concussions are alike. In addition, some symptoms present right away, while others can take days or weeks to develop.

According to Vernon (2005), physical, cognitive, and behavioral symptoms may all result from sustaining a concussion including headaches, difficulty concentrating and irritability. The ‘win at all cost’ mentality brought on by parents, teammates and coaches at a young age, needs to be eliminated. The sport should be made more about participation and learning. This may have a profound impact on minimizing the risks involved with playing sport. Another crucial step is educating parents, coaches and youth athletes of the signs and symptoms. This may decrease the rate of concussions and increase proper recognition and management of the injury moving forward.

Diagnosis of Concussion

A concussion cannot be compared to a broken arm. It does not show up through an X-ray or an MRI. To accurately monitor the injury, proper visualization of its effect on a person's cognitive and motor performance is needed (Giza et al., 2013). Currently, the medical profession uses fMRI and CT scans to eliminate all possible brain injuries that may have occurred. If no brain injury is diagnosed through the technology; a medical professional can use that information to assist in making an accurate concussion diagnosis. Examing visual disturbance, pupil dilation, balance, motor skills, cognitive abilities and/or loss of consciousness are keys in diagnosis of concussion (Moser, 2007). Furthermore, these symptoms may last less than fifteen minutes and may indicate a mild concussion has occurred Nuwer, M. (1997). Studying the multiple symptoms associated with concussions will prove essential to understanding the degree of the concussion injury.

Medical and past histories are vital contemplations. For example, the head is examined for indications of injury including the potential for skull or facial bone crack (Lubar, 2003). The neck may also be assessed since neck injury could be connected with head trauma. Patients who take blood thinners (i.e., warfarin or dabigatran) are at higher risk for bleeding when hit in the head (Karadivas, 2005). Physical examinations incorporate a complete neurologic examination and may incorporate searching for shortcoming, loss of motion, or change of sensation in the body (Karadivas, 2005). Equalization and coordination may also be assessed (Thonpson, 2006). Further, vision and listening may likewise be checked. Understanding the many layers of concussion diagnoses could prove essential to the discovery of interventions to help with concussions.

According to Vernon et al. (2003), diagnosis of a concussion is as complex as the symptoms that present. The challenge is developing positive tools for the 20% that struggle with long-term effects during recovery. These symptoms may last for weeks, months or years interfering with sport, school and daily life (Vernon et al., 2003). Recording what happened to the patient is a paramount initial phase in the judgment and treatment of a concussion (Egner & Gruzelier, 2001). The medical history will assist in determining whether there was an underlying medical issue that created the injury (Hammond, 2005).

Concussion symptoms. Symptoms usually reflect a functional disturbance to the brain, and may include physical (e.g., headaches, nausea), cognitive (e.g., difficulty with concentration or memory), emotional (e.g., irritability, sadness), and maintenance (e.g., sleep disturbances, changes in appetite or energy levels) symptoms (Giza et al., 2013). Concussions are considered mild (the least severe) in the highly debated categorization of Traumatic Brain Injury (TBI). The signs and symptoms of concussions typically fall into the four categories of physical, cognitive, emotional, and sleep with patients experiencing one or more symptoms from one or more categories. TBI can be defined "as an alteration in brain functions, or other evidence of brain pathology, caused by an external force" (Menon, Schwab, Wright and Maas, 2010). Graham et al. (2014) states,

> The lack of reliable biomarkers for concussions and the reliance on a subjective symptom-based definition, combined with variations in terminology (e.g.,"concussion" versus "mild traumatic brain injury") and in the definition of those terms, as well as evolving descriptions of the severity of concussion (e.g., grading scales, simple versus complex) pose challenges not only for understanding the epidemiology of sports related concussion but

also for interpreting the information on concussions that is available (p. 6).

To clarify further, TBI does not represent a single condition, but rather refers to several brain injuries of different types, and the severity associated with the determined cause. If there is a clearer definition, diagnosis and treatment of TBI, then I believe there will be greater understanding of the definition, diagnosis and treatment of injuries that fall under TBI (ex. concussions).

The many symptoms that a concussion may have make the injury very complicated to rehabilitate with the same standard protocol. The three main areas symptoms occur are, physical, cognitive and behavioral. The signs of these symptoms may be headaches, poor concentration and anxiety (Vernon, 2005) (see Appendix A). Furthermore, an individual could be experiencing cognitive symptoms and behavioral symptoms at the same time during recovery. The symptoms also play a pivotal role in recovery because some symptoms might be short and temporary and others appear long after psychical symptoms have passed. The long terms effect is where psychological setbacks have the greatest impact (Moser & Schatz, 2012).

There are many short and long-term effects that may occur following a concussion. Short term effects can last anywhere from a few days to a couple weeks (Vaschillo et al., 2002). These can include headache, photophobia, difficulty concentrating, short-term memory issues, poor balance and insomnia (Blume, Lucas & Bell, 2011). Research has shown that once an athlete has sustained a concussion, the athlete is at a higher risk of sustaining a second concussion. Long-term effects can include memory loss, early onset dementia/Alzheimer, emotional distress, depression, chronic traumatic encephalopathy and increased risk of suicide (Moser & Schatz, 2012). These long-term effects are usually more apparent in athletes who have

sustained multiple concussions or repetitive sub concussive hits to the head such as boxing, football, hockey or soccer players. Due to this fact correct concussion management protocol needs to be administrated by the responsible parties involved.

Concussion Management. Concussion management has a number of factors associated with the management protocol. The research will examine the implications of education, awareness and return to play guidelines.

Education. Education of athletes, parents, coaches and training staff who are affiliated with the sports teams has improved over the last couple of years (Lear & Hoang, 2012). It is essential that all parties involved are educated so that appropriate management is taken. The research that is coming out weekly on the negative implications of the mismanagement of the injury could potentially lead to severe consequences (Lear & Hoang, 2012). This is why it is imperative a medical doctor specializing in head trauma lead the management of return to play. More education pertaining to the importance of reporting concussions and the signs and symptoms to look for must continue in schools and in informational packages to parents and coaches. The more we educate the more control over this injury may be attainable (Lear & Hoang, 2012).

Awareness. Concussion diagnoses continue to increase among the athletic population each year. However, there is still room to improve knowledge regarding concussion awareness, recognition and management among parents and coaches of youth athletes (Tanis, 2008). In a study by O'Donoghue et al (2009), youth sport coaches in contact sports were found to have a moderate knowledge of sport-related concussions with a mean score of 84% (Zafonte, 2011). In a study by Coghlin, Myles and Howitt (2009), they reported that 76.32% of parents incorrectly assumed that an

athlete must lose consciousness to be considered a concussion (Zafonte, 2011). To help protect youth athletes, educational efforts must continue in order to increase concussion knowledge among parents and coaches thus creating efficient and correct concussion management.

Concussions are evaluated utilizing several different methods. These methods include subjective information from the athlete, balance testing, cognitive questions and neurocognitive testing (Robbins, 2000). Although there has been a great amount of research with college and professional athletes, there is little research on specific management guidelines for youth athletes, specifically under the age of fourteen (Bonfield, Wecht & Lunsford, 2014). The trouble with youth athletes is baseline cognition may be difficult to assess due to rapid cognitive development seen during childhood (Pfurtscheller & Kimesh, 1991). As with all post-concussion protocols, youth athletes should not return to play until all symptoms have resolved and a medical doctor has provided clearance.

Return to Play Guidelines. There is no single return to play guideline used for the entire athletic population. One component shared by all return to play guidelines is that an athlete should not begin a progression until fully asymptomatic (Blume & Hawash, 2012). Most return to play guidelines follow the 2012 Zurich Concussion Consensus Statement and/or Cantu's return to play guidelines. Both protocols outline six steps that guide athletes back into full contact play (see Appendix B). Another widely return to play guideline is a seven-day progressive return to play protocol used by medical professionals for youth athletes (Makdissi et al., 2013). This protocol starts with no physical or cognitive exertion and ends with full return to play. Without proper rest, symptoms can be magnified during or after cognitive or physical activity (Makdissi et al., 2013). Return to play protocols focus on physical symptoms but how

do practitioners know that a person is psychologically ready to return? Psychological symptoms are much more difficult to diagnose and innovative methods are needed, this therefore leads to the employment of biofeedback.

Biofeedback

Biofeedback is one of the earliest behavioral treatments and has been practiced in clinical settings since the 1970's. From its inception, biofeedback has had numerous definitions. Although a consensus about an ideal definition of what biofeedback is has not been reached, the most comprehensive and less controversial definition used for the purposes of the present investigation is the one provided by Schwartz (2010). Schwartz, defines biofeedback as: A group of therapeutic procedures that uses electronic or electromechanical instruments to accurately measure, process, and feedback, to persons and their therapists, information with educational and reinforcing properties about their neuromuscular and autonomic activity, both normal and abnormal, in the form of analog or binary, auditory, and/or visual feedback signals.

Best achieved with a competent biofeedback professional, the objectives are to help persons develop greater awareness of, confidence in, and an increase involuntary control over physiological processes that are otherwise outside awareness and/or under less voluntary control, by first controlling the external signal, and then by using cognitions, sensations, or other cues to prevent, stop, or reduce symptoms (Schwartz, 2010) (p. 35).

Biofeedback achieves successful results through psychophysiological (mind-body) self-regulation (Thompson & Thompson, 2006). Today, physicians, clinical psychologists, physical therapists, drug rehabilitation counselors and sport psychologists use biofeedback to treat and manage a number of disorders. During a

biofeedback session, individuals are trained on electronic monitors to exert control over vital bodily processes, such as heart rate, respiration, skin conductance, muscular tension and brain activity (Schwartz, 2010). When the individual observes and monitors shifts in bodily functions or striate muscle activity, participants learn to adapt and modify their mental and emotional responses to alleviate symptoms and help regulate specific health conditions (Thompson & Thompson, 2006).

The foundational principle for the use of biofeedback is that the patients able to gain conscious control over subliminal but undamaged upper neuron pathways. This is done through the artificial proprioception provided by the biofeedback equipment. The upper neuron pathways are in turn able to fix the missing or damaged function. This allows the participant to develop self-regulation skills that play a key role in improving health and overall wellbeing of the body and mind connection (Bechly et al., 2013). When put together, the word biofeedback means returning the biological knowledge created by the origin to origin in order to make the origin understand and control that knowledge for improved outcome measures (Thompson & Thompson, 2006).

Biofeedback equipment and technology

Biofeedback utilizes electronic sensors, or electrodes, attached to different parts of the body to detect changes in physical responses (Thompson and Thompson, 2003) (see Appendix C). Signals then inform the individual of these changes by means of visual or auditory signals such as a light displays or beeps. The individual begins to recognize thoughts, feelings, and mental images that can influence positive physical reactions when he or she views or listens to positive or negative feedback. By monitoring this mind-body connection, the individual can use the same thoughts, feelings, and mental images as indicators to become more relaxed or to calm the

heartbeat, control skin conductance, body temperature, brain wave patterns and other body functions (Thompson and Thompson, 2006).

Within biofeedback there are several different ways to measure outcomes. For example, a sensor is used to measure an individual's respiratory rhythm, the respiratory rhythm is transformed from a constantly varying number into a graphic display (e.g., a windmill that has its blades turning according to the individual's respiratory rhythm (Johnston et al., 2010). The individual looks at a screen with the windmill displaying his/her on-time respiratory rhythm. The biofeedback practitioner helps the individual to target ideal ranges of respiratory rhythm; this can be done by setting a threshold (e.g., six breaths per minute). When the respiratory rhythm is within the targeted threshold, a stimulus is provided to the individual (e.g., an auditory stimulus, or the windmill changing colors from red to blue) (Guskiewicz, 2013). The correlation between the physiological change and symptom/performance in this case is that lower respiratory rhythm correlates with lower anxiety (Harkness, 2008). After having the biofeedback concept defined, it is also important to understand the theoretical reasoning grounding its use as a therapeutic procedure, and as a procedure to enhance performance.

The main model, adopted by numerous biofeedback authors, is based on the premise of a communication change between the body and brain, which changes an individual's physiological state. (Blumenstein, Bar-Eli, & Tenenbaum, 1997; Collins, 2002; Peper & Schmid-Shapiro, 1997; Strack, 2003; Vernon, 2005). A useful example to elucidate this model is the direct correlation between respiratory rhythm and anxiety (Lehrer, 2003; Meuret, Wilhelm, Roth, 2001). Biofeedback techniques are used to assist with the regulation of an individual's respiration pace. A decrease in respiratory pace correlates with an expected decrease in the anxiety that a person experiences (Blumenstein, Bar-Eli, & Tenenbaum, 2003).

While involved with biofeedback, the participant will try to remember what their thoughts and feelings were at the moment and deliberately maintain them to keep the respiration pace low. The result of training, the individual learns to control the targeted physical responses (i.e., six breaths per minute) and over time, is able to recognize what is required to reduce the problematic symptoms. Unlike being prescribed medication to manage symptoms, biofeedback eventually becomes unnecessary as the individual learns to perceive internal physical responses and make the desired changes. The participant then has a powerful, portable, and self-administered treatment tool to deal with problematic symptoms that are caused from receiving psychological setbacks from a concussion.

Biofeedback and physiology assessment. It is crucial to clarify an important distinction between biofeedback and physiological assessment. The first, as previously defined, has an information component fed back to the subject, either by an auditory, visual, or sensory signal using a biofeedback apparatus (Gasquoine, 2007). Unlike biofeedback, physiological assessments only measure an individual's physiological information. The physiological data may be translated into an intelligible format but only for analysis purposes. Since the data is not informed back to the participants, thus, it may not use the data as a reference to make changes to their own physiological responses (Derfel, 2006). Biofeedback, in contrast, displays the data to the individuals as a reference to assist them to regulate physiological states for a specific purpose.

Biofeedback equipment allows scientists, practitioners, and researchers to make use of different modalities, different sources of physiological assessment, and feedback (Crews & Landers, 1993). The modalities include, among others: heart rate, heart rate variability, skin conductivity, skin temperature, brain activity, muscle activity, respiratory rhythm, body balance, and blood volume. Such facts emphasize the need

for clarification of the array of modalities available and the terminologies and abbreviations used.

Research in Biofeedback Non-Sport that Correlates with Concussion

Research in biofeedback in a non-sport context had proven to be beneficial with overcoming substance abuse, anxiety disorder and headaches management. It is important to focus on these three non-sport issues because outside of sport, individuals who have sustained a concussion may experience these setbacks.

Substance abuse. Research has shown that biofeedback has assisted relaxation training to deal with alcoholism and its related symptoms (e.g. depression and anxiety) (Sharp et al., 1997). Instead of resorting to alcohol when feeling depressed or anxious the individuals were able to focus on their breathing, which prevented them from drinking. By controlling your breathing when feeling depressed or anxious it allows the individual to communicate positive messaging to the brain (Peniston & Kulkowsky, 1989).

Generalized anxiety. Biofeedback EMG and skin conductance modalities are effective for anxiety reduction (Hurley & Meminger, 1992). With EMG training the participant learns to control and relax muscle when subjected to adverse stimuli. Roome and Romney (1985), found an advantage for the biofeedback training when looking at children experiencing generalized anxiety disorder. They compared progressive muscle relaxation to EMG biofeedback training. A similar study was carried out by Sarkar, Rathee, and Neera (1999), by comparing the generalized anxiety disorder response to pharmacotherapy and to biofeedback. The results indicated that the biofeedback had a better effect on symptom reduction.

Headache. A study by Hermann & Blanchard (2002) used thermal biofeedback to alleviate headache activity in children. The results were highly successful as more than two thirds of the children could be classified as treatment successes based on an accepted criterion of 50% symptom reduction. The specific technique used to increase temperature by the participants is to rub both hands together. Increasing your body temperature through hand warming has been shown to increase alertness and reduce headaches. There were significant clinical improvements, and six months after the study, 80% were headache-free.

Heart rate variability (HRV) biofeedback

Heart rate variability is not a focused outcome for the research but needs to be understood when doing biofeedback respiration training. The technique of regulating respiration rate to alter emotional and psychological states has been used for centuries. The practice of meditation, which involves slowing one's breathing to create a sense of emotional calm, traces back at least 2,500 years. Research shows that Catholic rosary prayer and yogic mantras produce patterns of approximately six breaths per minute (Bernardi et al., 2001).

In the 1960's, scientists argued for the existence of resonance in the cardiovascular system observed when breathing at a rate of 5 or 6 breaths per minute (Angelone & Coulter, 1964). A Russian physiologist in the 1980's, Evgeny Vaschillo, worked with cosmonauts to determine what breathing rate produced the greatest variability in heart rate and what relationship existed between changing heart rate and autonomic functioning (Boden, 2003). The course of the next two decades of research in heart rate variability biofeedback has grown steadily to include applications designed to optimize physical and emotional health and to improve hypertension,

hypotension, asthma, anxiety, and depression.

Studies show that HRV biofeedback produces significant shifts in total power in heart rate spectral analysis toward the low frequency range (Lehrer et al., 2003; Lagos et al., 2008; Strack, 2003; Vaschillo et al., 2002; 2006). Such results suggest that HRV training results in an improved ability to regulate activity in the autonomic nervous system, and in certain cases, has been associated with behavioral performance improvement. Strack (2003) observed performance improvements after designing HRV biofeedback training to improve hitting in high school baseball players. The results showed a 60 percent improvement in batting performance in the HRV training group verses a 21 percent improvement in the control group. However these results may be somewhat convoluted by the speed of the pitching machine being unintentionally set for five mph slower during post-testing as compared to pre-testing (Gruzelier et al., 2006).

In Lagos et al.'s (2008) case study, a fourteen-year-old golfer reduced his season average strokes on an 18-hole course to 76 strokes after ten weeks of HRV training, from 91 strokes in the season prior to the training. Previously, Bessel's (1997) study investigated the effects of breathing retraining and a cognitive intervention on reducing anxiety in gymnastics performance. The breathing retraining group and cognitive intervention both improved significantly when compared to the control group. Gymnasts aged 10-18 selected the event (vault, bars, beam or floor) where they experienced the most anxiety in conjunction with competition for targeted breathing training. Results revealed an increase in scores by six percent for the breathing retraining group, four percent for the cognitive intervention group, and no improvement for the control (Garet et al., 2004). These results for performance improvement seen from breathing and HRV training are contrasted by those seen in

Tanis' (2008) study, where no performance improvements resulted. However, this may relate more to the nature of measurement, a coach-rated performance on four volleyball skills during games, than the true outcome of biofeedback training.

Neurofeedback

This is not the focused intervention of the study; however, it is important to understand how it works in correlation with biofeedback. In the late 1800s, scientists first discovered that the brain produces electricity and developed instrumentation to record this electrical activity (Robbins, 2000). By the early 1900s, a handful of scientists avidly collected brain wave data despite uncertainty regarding its meaning. In fact, this phenomenon remains somewhat of a scientific mystery to this day, with most knowledge in the field of neurofeedback based on observed outcomes and associations (Landers et al., 1991).

In a 1958 research study, an individual demonstrated that he could correctly identify the attainment of specific brain wave frequencies. The experiment required the subject to change his mental state in order to produce the desired patterns, and the researcher confirmed that the subject indeed had correctly produced the targeted pattern (Robbins, 2000). This important finding, as evidenced in electroencephalography (EEG) recordings, demonstrated that conscious control could be exerted over mental state.

The idea of using neurofeedback to improve performance outcomes derives its basis from associations (Vernon, 2005). Neurofeedback employs EEG patterns identified during optimal performances to subsequently train brain wave activity with the intention of producing repeated optimal performance (Hasset et al., 2006). The assumption that neurofeedback training will result in a change in EEG patterns, which

will result in changes in behavior underlies all intervention studies.Yet the relationship between EEG training and behavior is not fully understood (Egner et al., 2004; Robbins, 2000; Thompson & Thompson, 2003).

The brain is complex and tools to measure electrocoritical activity are somewhat blunt. In that, sensors placed on regions of the scalp can only imperfectly measure activity from the many layers and subcortical structures below, creating the potential for misperception (Guskiewicz, 2004). Present-day neurofeedback technology cannot achieve precise delineation of which structures or areas of the cortex produce particular activities. Nonetheless, the idea persists that expert-like behaviors can be taught to improve and create consistency in performance outcomes

Research in Biofeedback and Sport

This review will include work targeting outcomes directly and indirectly linked to sports performance. These include development of strength; ability to relax before and during competitions; enhanced focus for the performance of sports tasks; objective sports skills, abilities, and overall performance (e.g., running and swimming speed, passing and shooting accuracy in basketball, golf putting accuracy) (Peper & Schmid-Shapiro, 1997). The present search considered work found between the years of 1976 and 2012, as research in biofeedback may be traced back to 1976. This is when Dorsey completed a dissertation on EMG biofeedback work geared toward gymnasts' performance enhancement.

Research in the late 70's investigated the effect of EMG biofeedback training on state anxiety of gymnasts and on their performance. It involved participation of 35 members of a university level gymnastics team who were considered to have high levels of anxiety. It was an assessment, which was made either by their coach's

evaluation or by the athletes' score on the Spielberger State-Trait anxiety scale (Moser & Schatz, 2012). Dorsey's design consisted of two intervention groups and a control group. The first intervention group underwent EMG biofeedback training, and the second underwent relaxation-training sessions, while the control group had no training but regular gymnastics training routines. The results indicated that the EMG group had better results for lowered anxiety, followed by the relaxation group, with the worst means found in the control group.

Another investigation conducted in the dissertation by Dorsey (1976) was to find whether the improvement in relaxation affected the gymnasts' competition performance or not. Dorsey found that the results had no statistical significance, providing two explanations. First, the author believed that the number of participants was not sufficient. Second, that relaxation affects performance differently, depending on the type of gymnastics apparatus that the athletes are competing on (Karadivas, 2005). The fact that Dorsey randomly assigned groups with participants that competed in different gymnastics apparatus within the same group may have limited the quality of the analysis (Lubar, 2003). Although a stratified selection would have decreased the number of participants even further, such an approach would have provided a much more detailed analysis of the effect of the different training on performance enhancement (Janelle et al., 2000).

In the same year, Lawrence Klein and NoryLaderoute called "Mind over Muscle" created a biofeedback-based training program for improved performance for athletes. The program included a printed guide, audio tapes, and portable skin resistance biofeedback equipment. An updated DVD version was released years later (Hatfield & Hillman, 2001). The program provides biofeedback-based relaxation and visualization training. The printed material has orientations, terminology, and

explanations about biofeedback and its correlation with performance (Hatfield et al, 2009). “Mind over Muscle” was used by numerous professionals and teams, including the Canadian Olympic team, by military programs, and by Bruno Demichelis, an authority in biofeedback training for sports (Guskiewicz, 2013). This training program has been used with considerable frequency due to its objective and straightforward approach. Its popularity was because it was developed by professionals who were able to simplify the use of biofeedback for athletes and for performance professionals in sports (Gordon, 2000).

Bernardi (2001) investigated the effect of an EMG biofeedback intervention on young athletes’ anxiety and performance. The selection of participants for this research used the Sports Competition Anxiety Test (SCAT); 261 individuals of ages between 10 and 13 took the SCAT. Eighty had high scores; they were randomly assigned to either a control group or a biofeedback intervention group. A random selection assigned 10 participants per group to participate in the research (Bernardi et al., 2001). Bernardi made use of a simulation instead of a real competition, because he intended to control variables such as audience influence, quality of the opponent, and the effect that success or failure in the competition had on each athlete (Bloom, 2004).

The competition consisted of participants trying to keep balance when on a stability platform for the longest period of time they could (Cottyn et al., 2006). The method entailed a baseline session and five simulated matches in which the control group had no feedback whatsoever. On the other hand, the intervention group received feedback of their muscle activity levels (as indicators of anxiety—higher muscle activity correlated with higher anxiety). They attempted to use the information to decrease anxiety before the competition (Deeny et al., 2003).

Results showed that participants who had received biofeedback displayed less variation on their frontals activity before the competition when compared with the control group. The author traced a correlation between this result and the amount of focus athletes showed before competitions (Egner & Gruzelier, 2003). One of the author's hypotheses was that the group that received EMG biofeedback would have better performance when compared with the control group. Statistical analysis showed no significant differences confirming the null hypothesis.

Another hypothesis was that state anxiety would also differ between the groups, a hypothesis which was also not confirmed because of the absence of significant statistical findings (Ericsson, 1996). The only statistically significant result was on trait anxiety, in which the treatment group showed lower results after the training during the simulated competitions. The research accounted for variables that could be important sources of anxiety depending on the characteristics from each athlete. These included the presence of spectators, quality of the opponent, and success or failure in the competition (Karadivas, 2005). A design comparing the effect of EMG intervention across groups would provide interesting data to further ground the effect of biofeedback on performance and on reduction of competitive anxiety (Lagos et al., 2008). This would be done with groups controlling for the anxiety-related variables, while others were exposed to the variables.

A few years later, in 1980, a publication by De Witt presented two separate studies investigating the effect of biofeedback training to reduce stress associated with sports competition. In the first study, the participants were six university football athletes who had, according to their coach, displayed consistent stress during competitions. The author conducted a survey and determined that most football athletes reported tension on the frontalis, trapezius, and masseter muscles. Therefore, De Witt

administered 12 sessions, lasting 30 minutes each, with EMG biofeedback training. The goal was to diminish the tension level in the aforementioned muscles.

According to De Witt (1980), each session consisted of "(a) clinical interview and assessment; (b) EMG recording without feedback for 2 minutes; (c) general relaxation training; and (d) specific myographic feedback, cognitive training, and discussion." (p. 289). He used an initial interview with each athlete to determine which muscles were more affected by stress and by football performance problems related to stress. It was the first time in the literature that individual characteristics were taken into consideration regarding the development of the interventions. This is an important factor to be taken into consideration in the subsequent meta-analysis of the studies.

During the sessions, each athlete was asked to visualize scenarios associated with stress, while also asked to keep EMG activity within a specific range. The range was either determined by an initial baseline or by activity range associated with a relaxed state (< 2 microvolts for the frontalis). The results indicated that EMG biofeedback sessions assisted athletes to significantly decrease muscle tension levels. Moreover, performance ratings showed significant differences after the intervention period, with further support from the coach's report that four of the six players improved their performance during competition.

De Witt's (1980) second study included 12 basketball players, randomly assigned to either a control group, or an intervention group with 11 training sessions, lasting 60 minutes each. From the 11 sessions, two were EMG and heart-rate biofeedback sessions, while the others consisted of mental rehearsal and cognitive behavior regulation training sessions. The author used performance ratings administered before and after the training program for the comparisons. Team

managers who were unaware of the training program gave the ratings. The results reported by De Witt showed significant difference between the control and intervention groups' performance rating averages (ratings which were given by the coaching staff), with a higher average for the intervention group. The author also found that there was a significant decrease in the athletes' heart rates and muscle activity comparing the results from the first and last sessions.

Both studies by De Witt reported important findings on the effect of biofeedback training on physiological control and on sports performance. However, results could have been even more significant for practical applications and for the scientific field. This would have been the case had the author used objective measurements for the performance assessments instead of performance ratings. In addition, more similar methods for the two studies would have allowed further comparisons and a generalization of the results.

Daniels and Landers (1981) published their study on the effect of heart rate or respiratory biofeedback training geared toward the improvement of psychophysiological patterns and improved performance for competitive shooters. It was the first time in the literature that heart rate and respiratory biofeedback were used in regard to sports performance enhancement (Prinzel et al., 2002). The design consisted of separating eight shooters, with at least 7 years of experience in shooting, into two groups of four. The first group received auditory biofeedback and the second received verbal instructions and no biofeedback. Much like DeWitt (1980), Daniel and Landers (1981) used an initial assessment to determine individualized bio physiological characteristics to be fed back to the athletes.

The authors investigated if respiratory patterns, heart rate, or heart cycle were

affecting shooting performance (Ravizza, 2006). Characteristics detrimental to shooting performance, according to the authors were elevated heart rate before the shot, holding breath too long before the shot, and shooting in the middle of a heartbeat. The biofeedback training consisted of five sessions of 40 shots. The shooter received auditory feedback to regulate ideal patterns for optimal performance or "targeted response" (Daniels & Landers, 1981). The authors used an interview method to determine the level of awareness that each participant had about their bio physiological characteristics before and after the training (Strack, 2003). Participants in the biofeedback group showed significant improvement on awareness when compared to the control group after the training.

Further findings by Daniels and Landers (1981) demonstrated that participants in the biofeedback group showed significant statistical improvement in shooting performance and in shooting performance consistency when compared to the control. The abovementioned findings by Daniels and Landers were important references for the applied use of biofeedback training for sports. More specifically, for sports that demand a high level of precision from the athlete, such as shooting and archery.

Muscle strength and adequacy in connection to sports tasks are among the main attributes of successful athletes. Thus, work investigating muscle strengthening programs with the use of biofeedback are relevant to the present discussion. The first study in the literature to investigate the use of EMG biofeedback as an aid to muscle strengthening was conducted by Lucca and Recchiuti (1983). The author separated 30 female university participants into three groups of 10 participants each: a control group, an intervention group training with isometric exercises, and a third group training with isometric exercises and EMG biofeedback (Peniston & Kulkowsky, 1989). The EMG was used to provide participants with auditory feedback about ideal

muscle tension levels during the isometric exercises.

The results indicated that the isometric exercises group improved muscle strength at a slower pace than the group that received EMG biofeedback (Meehan, 2009). Lucca and Recchiuti (1983) reported that a 19-day period was sufficient for the biofeedback and isometric exercise group to achieve significant improvement in muscle strength and torque. In another study, the same period of time was not enough for the isometric exercises group or for the control group to achieve similar results (Martens, Vealey & Burton, 1990). The investigation by Lucca and Recchiuti (1983) is a very important reference for work in muscle strengthening. The use of EMG biofeedback and isometric exercises shortened the time necessary for muscle strengthening, which is important information for trainers involved in athletes' preparation and in muscle recovery after long periods of forced rest (e.g., after injuries or after vacations) (Lehrer, Vaschillo & Vaschillo, 2000).

In the same year, Peper and Schmid (1983) published an article about the use of electro dermal biofeedback to assist members of the U.S. Rhythmic Gymnastics Team to improve performance. The authors highlighted that an important part of the biofeedback training was to demonstrate to all participating athletes that thoughts affect the body (Kontos, 2004). For this purpose, the authors had an athlete monitored for skin response with the auditory feedback being heard by all participating athletes. Peper and Schmid (1983), asked the athlete to picture herself in an embarrassing situation, and the auditory feedback immediately rose to a higher level as the participant's skin resistance levels raised (Hatfield et al., 1984).

The researchers to assist athletes to become aware of their progress during physiological relaxation sessions used the same electro dermal auditory feedback. The

authors then implemented the feedback to assist athletes to perceive stressful circumstances when mentally rehearsing their competition routines (Hanslmayr et al., 2005). Finally, the authors set up a training method for improvement of concentration. Athletes were given skin resistance biofeedback while other team members tried to create diversions to affect the athlete's focus (Gruzelier, Egner & Vernon, 2006). The authors concluded the article by emphasizing that biofeedback was very useful as a teaching tool and in providing assistance for other mental training techniques.

The article by Peper and Schmid (1983) represented a great contribution, because it focused on the use of biofeedback for athletes' performance enhancement from a practical elite level perspective. It also included instructional steps during preliminary stages of the biofeedback intervention, which is a great reference. The lack of statistical data is without question overshadowed by published statements about the successful use of biofeedback in practical settings and for athletes at an Olympic level (Hammer & Saul, 2005).

Benefits of Biofeedback for Improving Performance

Based on the results of Hatfield et al. (1984) and Salazar et al. (1990), Landers et al. (1991) undertook a study to see if a reduction of alpha in the left hemisphere prior to a shooting task could be trained and if so, what impact it might have on performance. The study was divided into three groups: a group trained to shift the level of cortical activity towards more negativity in their left temporal region (correct feedback); a group trained to shift the level of cortical activity towards more negativity in their right temporal region (incorrect feedback); and a non-contingent control. At this time, the focus of neurofeedback interventions was to create slow potential cortical shifts, and the study was modeled after other work that was part of the slow potential

feedback paradigm (Wilson & Gunklenman, 2001).

It is now considered more efficient to target specific frequencies with neurofeedback training, such as specifically increasing the amplitude of alpha in the left temporal lobe, rather than shifting cortical activity so that there is movement in the negative direction in time before a shot is executed (Vernon, 2005).

In the post-test in Landers et al.'s (1991) the 'correct feedback' group showed significant performance improvements, while the 'incorrect feedback' group showed a significant decrease in performance. The control group showed no change in performance outcome (Zafonte, 2011). The 'incorrect feedback' group showed an increase in beta (considered 13-30 Hz in the study) activity as a result of the low frequency training. This was assumed to create an increase in conscious processing, which led to a decrease in the archers' performance of a well-learned task.

The significance of Landers et al.'s (1991) study was to provide evidence that training participants with 'correct feedback' can create performance improvements. And, that training with 'incorrect feedback' can lead to performance decrements on skilled tasks (Vernon et al., 2003). The results showed that inappropriate EEG activity, in this case due to 'incorrect feedback,' was detrimental to performance outcome. Inappropriate EEG activity due to over arousal or anxiety in the time leading up to performance happens in natural competition settings. It may be responsible for suboptimal performance outcomes in high level athletes executing well learned tasks (Vernacchia et al., 2000). It is notable that while an increase in alpha power in the right hemisphere was the target of the "incorrect feedback" group, the result was an increase in beta. This provides evidence of the effect of training a targeted reward or inhibits band and observing consequent changes in other non-targeted bands.

Although the number of studies on the use of biofeedback for sports performance purposes is still very limited, it has been the focus of a growing number of researchers and practitioners throughout the past decades (Nestorius et al., 2008). The number of publications and reports of applied work focusing on the use of biofeedback in sports has grown significantly since the late 1970s (Porges, 1995). These investigations or reports of applied work included both work focusing on outcome measures that indirectly affect sports performance (e.g., relaxation prior to competitions, development of muscle strength, and development of flexibility) (Sterman & Egner, 2006), and work focusing on outcome measures that directly affects sports performance (e.g., shooting accuracy, passing accuracy in basketball, batting averages in baseball, and overall volleyball performance).

A calculation of percentages performed in present studies shows that before the 2000s decade, most of the reported work (76.5%) focused on outcomes that were indirectly related to sports, while only 23.5% focused on outcomes directly linked to sports performance. From the year 2000 until 2012, this trend reverses because most of the work (69.2%) focused on outcomes directly linked to sports, while 30.8% accounted for outcomes indirectly linked to sports (Moser & Schatz, 2012). Besides the escalating number of scientific publications using biofeedback geared toward outcomes directly linked to sports performance, there is the growth of the applied use of biofeedback in competitive sports (Blumenstein et al., 2002).

Olympic athletes have been making use of biofeedback training to enhance performance in the last few decades (Blumenstein & Lidor, 2007; Dupee, 2008; Hammond, 2005; Harkness, 2008; Pop-Jordanova & Demerdzieva, 2010). An example of this phenomenon is Abhinav Bindra, an Olympic shooter from India. He trained with a biofeedback specialist, Timothy Harkness. Bindra underwent heart rate

variability biofeedback training to achieve control of parasympathetic responses prior to and during shooting competition. Bindra was also trained with the use of brain activity biofeedback to develop focus and avoid interior monologue while shooting (Harkness, 2008). Bindra won a gold medal in the Summer Beijing Olympics in 2008.

Besides Olympic athletes, professional teams are beginning to make use of biofeedback for; performance enhancement, prevention of injuries, assistance with the recovery of injuries, and with practices to assist athletes' with sleep and rest management (RadIo et al., 2002). A. C. Milan, an Italian professional soccer club, was the pioneer in implementing biofeedback for athletes. The club has created a center for applied sciences including biofeedback, neurofeedback, and other practices (e.g., kinesiology, athletes' activity tracking, and athletes' move tracking). The center, named Milan Lab, may assess or train up to six athletes at the same time (Derfel, 2006). Among the training offered to athletes is the development of self-awareness of muscle activity, tension, and muscle fatigue during the game. This is done to provide players with information that assists them to use adequate amounts of effort during a game to avoid injuries. Further biofeedback-based training include enhancement of focus, improved field awareness, and fatigue control during games and during practices, among others (Raymond et al., 2005).

Other professional teams have followed A.C. Milan's efforts opening similar centers for their athletes. These teams include Chelsea F.C., a professional soccer team in England (The Telegraph, 2009), and The Vancouver Canucks, a professional ice hockey team in Canada (The Vancouver Sun, 2009). Even though the number of practitioners and researchers working with biofeedback in competitive sports is still very limited, the aforementioned growth in the applied use of biofeedback in competitive sports may have happened due to the growing number of scientific studies

being produced, and due to the technological advances that have made biofeedback equipment portable (McCraty et al., 2003).

Nowadays, researchers and practitioners can use biofeedback interventions during practice, because biofeedback apparatuses allow data to be transmitted to a remote computer through the use of wireless technology (Moser, Glatts & Schatz, 2012). This characteristic has broadened the biofeedback's applicability in sports, which may create a new trend in applied research for the use of biofeedback geared toward sports performance and for applied work in competitive sports. An important dynamic of biofeedback is ability to control and train the autonomic nervous system (Thompson & Thompson, 2006).

To clarify, the ANS is responsible for the unconscious control of the bodily organs (i.e., heart rate, digestion, respiratory rate) (Li, 2014). The autonomic nervous system is divided into two systems, the fight-or-flight response referring to the sympathetic nervous system and the feed and breed response referring to the parasympathetic nervous system (Costanzo, 2007). When these two systems are active, it can affect the physiological responses by either activating a response or inhibiting it (Schmidt & Thews, 1989). With biofeedback a person learns how these systems affect his/her physiology positively or negatively, thus giving the ability to have a positive behavioral outcome. It can be concluded most autonomous functions are involuntary but through biofeedback training the body can be trained to work in the somatic nervous system to have more control over negative behavioral outcomes The ANS and its two systems have a direct correlation to the effects of anxiety (Belvisi et al., 1992).

Anxiety

A major task in sport psychology involves helping athletes control their arousal

level in competitive environments. This is so that arousal does not lead to high levels of anxiety that interferes with performance (Landers et al., 1994). This can also be the case for individuals recovering from a concussion when applied to sport or life. Two types of anxiety have been identified in the literature: cognitive anxiety, which is the mental component (e.g., feelings of worry and apprehension) and somatic anxiety, which deals with physiological responses to stress (e.g., sweaty palms, butterflies feelings in chest area). Developing the ability to self-regulate arousal levels from adverse stimuli, may be a beneficial tool for managing the negative side effects of the concussion. The anxiety disorders described are, generalized anxiety disorder, panic disorder, social anxiety disorder and post-traumatic stress disorder.

Generalized anxiety disorder (GAD). Anxiety and worry are part of life. Anxiety can cause individuals to worry about a job, a sports event, family issues and personal problems. Furthermore, it can cause worry about near or distant future outcomes. Moderate anxiety is a normal and common human emotion (Stewart et al., 2007). Not only is anxiety a common human emotion, but a moderate amount of anxiety can help people, for example, to prepare for an exam, perform assigned work or give a speech.

When anxiety becomes persistent and repetitive providing negative outcomes for dealing with situations, the individual may be suffering from generalized anxiety disorder (GAD) (Mellalieu et al., 2006). GAD is probably caused by a combination of biological factors and life events (Stewart et al., 2007). In fact, many people with GAD also suffer from other medical disorders, such as depression or panic disorder because of anxious vulnerability. This can be influenced by certain brain chemicals such as serotonin and nor epinephrine that play a critical role in triggering and maintaining the disorder (Wilson et al., 2009).

Experts believe that the GAD is caused by a combination of factors: biological, psychological, and the result of one or more negative life events. It seems that the genetic influence is an essential component in the development of anxiety disorders (Mellalien et al., 2006). GAD is characterized by excessive and ongoing concerns about different topics or situations of everyday life. Concerns persist even when the person is not experiencing any major problems. At present, GAD is diagnosed when the duration of the concerns and constraints are actively argued for at least six months (Stewart et al., 2007).

People with GAD also experience multiple physical and emotional difficulties such as muscle spasms, restless sleep, irritability, impatience, restlessness, and difficulty concentrating. Individuals that have received a concussion also experience these types of symptoms. People who have grown up with a model of anxious and fearful educational environment are more likely to develop structures of thought and interpretations associated with danger (Wilson et al., 2009). The disorder usually appears between 25 and 35 years of age, but can begin in childhood. Increased levels of stress can often trigger the disorder. Leading up to the diagnosis of GAD many people report an increase in stressful events such as bereavement, illness, job loss or divorce (Brady & Bowd, 2005). The stress of positive events, such as marriage, birth of a child or a new job, can also trigger GAD.

Treatment. Fortunately, today there are behavioral and cognitive strategies that have proven effective in treating patients with GAD. The treatment that has shown better results in scientific research studies is the cognitive behavioral therapy, which intends to change the way that patients with GAD think about problem situations and how to respond to them. In some people, relaxation techniques, breathing training and exercise can decrease anxiety (Park & Lee, 2005). Furthermore, specific medications

can often be effective in relieving the symptoms of anxiety. Treatment programs should be adapted to the needs of each patient. In many cases, combination treatment of psychopharmacology and cognitive behavioral therapy can provide the desired positive outcome. Both strategies together help the patient's recovery.

The learning of tensing and relaxing muscle groups systematically, a technique known as progressive muscle relaxation, has helped a large percentage of people control persistent concerns and symptoms in GAD (Brady & Bowd, 2005). Other patients report that an exercise program of about 30 minutes per day or a brisk walk temporarily quiet some symptoms of GAD. Meditation, yoga, massage, relaxation and biofeedback are other instruments that can be highly beneficial. Controlled breathing, thoughts and focus on the present helps to reduce excessive anxiety. However, it is important to note that none of these strategies replaces a cognitive behavioral psychotherapy and pharmacological treatment.

Cognitive therapy is designed to reformulate concerns, giving individuals the ability to see situations in a more realistic way (Park & Lee, 2005). Patients can be trained to identify anxious and unrealistic thoughts and develop techniques to change their answers. Biofeedback training has provided positive outcomes measures for training and developing these techniques (Bernardi et al., 2001). Cognitive therapy can be supported by instructions to alter the behavior or changes in lifestyle to eliminate stress.

Panic disorder. Panic disorder is a condition characterized by sudden attacks of terror, usually accompanied by a pounding heart, sweatiness, weakness, faintness, or dizziness. During these attacks, people with panic disorder may flush or feel chilled hands tingle or feel numb; and experience nausea, chest pain, or smothering sensations

(Chamberlain & Hale, 2007). Panic attacks usually produce a sense of unreality, a fear of impending doom, or a fear of losing control. Fear of unexplained physical symptoms of oneself is also a symptom of panic disorder. Sometimes, people who suffer from panic attacks believe they are having heart attacks, losing their minds, or on the verge of death (Kais & Raudsepp, 2005). They cannot predict when or where an attack will occur, and between episodes many worry intensely and are terrified to think about the next attack.

Panic attacks can occur at any time, even while sleeping. An attack usually reaches its peak during the first ten minutes, but some symptoms may last much longer. Panic disorder affects about 6 million American adults and is twice more common in women than in men. Panic attacks often begin in late adolescence or early adulthood, but not all suffering from panic attacks will develop panic disorder (Hatzigeorgiadis et al., 2009). Many people have just one attack and never have another. The tendency to develop panic attacks appears to be inherited.

People who have repeated panic attacks can be very disabled by their condition and should seek treatment before they start to avoid places or situations where panic attacks have occurred (Chamberlain & Hale, 2007). For example, if a panic attack happened in an elevator, someone with panic disorder may develop a fear of elevators, which can affect their employment or housing decisions and restrict where that person can seek medical attention or enjoy entertainment. Some people's lives become so restricted that they avoid normal activities, such as shopping or driving activities (Kais & Raudsepp, 2005). About a third of these people simply live in their homes or are unable to confront a feared situation only when accompanied by a spouse or a trusted person. Research has begun to show that the trauma induced from sustaining a concussion may cause participants to experience panic attacks, leading to developing

the disorder (Makdissi et al., 2013).

Treatment. Early treatment can often prevent agoraphobia, but people with panic disorder may sometimes go from doctor to doctor for years and visit the emergency room repeatedly before someone correctly diagnoses their condition (Park & Lee, 2005). A panic disorder is one of the most treatable anxiety disorders, since in most cases it responds to medication or certain kinds of cognitive psychotherapy, which help change thinking patterns that lead to fear and anxiety. Biofeedback allows for the ability to monitor respiration rate which has been a key indicator to perform breathing training to overcome a panic disorder (Meuret, Wilhelm & Roth, 2001).

Often, panic disorder is accompanied by other serious problems, such as depression, drug abuse, or alcoholism. These conditions need to be treated separately. Symptoms of depression include feelings of sadness or hopelessness, changes in appetite or sleep patterns, low energy, and difficulty concentrating (Chamberlain & Hale, 2007). Most people with depression can be effectively treated with antidepressant medications, certain types of psychotherapy, or a combination of both.

Social anxiety disorder (SAD). Social anxiety disorder (SAD) is the most common anxiety that can have serious consequences for the sufferer. The key element of the SAD is extreme anxiety and fear caused by the possibility of being judged by others or behaving in a way that could be embarrassing or ridiculous. An individual who is required to spend an extended period of time away from a team or peer-group due to the recovery protocols of a concussion may begin to show signs of SAD when returning caused by the perceived negative judgment (Makdissi et al., 2013).

The person with SAD mistakenly assumes that all eyes are on him or her. Anxiety may take the form of panic attacks. This may include symptoms such as

palpitations, dizziness, shortness of breath and profuse sweating (Hatzigeorgiadis et al., 2009). Post-concussion recovery research is beginning to show a correlation between receiving a concussion and experiencing symptoms of SAD during the recovery period (McCauley et al., 2001). Interpersonal or social events are the biggest contributors to SAD. For some people, this kind of social obligations causes them to have inordinate fears and feelings that transcend and magnify nervousness. People usually get so anxious about the possibility of being criticized or ridiculed in public or by their peers, that it can cause life experiences to be painful or horrific.

Avoiding embarrassing situations can be the priority in their lives (Park & Lee, 2005). Potentially these reactions have not occurred, yet people with SAD usually try to avoid the feared situations, which are restricting the possibility of connecting or reconnecting with others. SAD can be selective. A person may feel an intense fear of a single circumstance, such as sitting for examinations or engaging in an affair, and yet feel totally comfortable in other social activities as a whole (Kais & Raudsepp, 2005).

It is believed that SAD is caused by a combination of biological factors and life circumstances. Scenarios may include having suffered a humiliating experience in public at an early age or the result of a parent-child relationship with unflattering social exchanges (Park & Lee, 2005). Like other disorders (such as diabetes or heart disease) this is determined by some genetic vulnerability, and environmental factors. There is always a relationship between how the person thinks, feels and behaves.

What happens in people with SAD is that the interpretive mode situations and their own performance in them are biased. Precisely, the modification of these biases will be one of the cornerstones of treatment (Wilson et al., 2009). People with SAD tend to underestimate their social skills. Sufferers are aware of the physical signs of

nervousness, such as blushing or sweating and think these are obvious to others. Anticipatory anxiety about one's behavior in public can become a self-fulfilling prophecy, because the extreme nervousness can result in poor performance (Stewart et al., 2007).

Treatment. Psychotherapeutic treatment aimed at specific techniques designed to help patients reduce their suffering is a therapeutic method that examines the beliefs and expectations of the individual in certain situations and subjective perception about their own performance (Stewart et al., 2007). Much of the work is the gradual exposure of the patient to producing social circumstances of fear (Wilson et al., 2009). Repeated exposure to the conflict situation serves to show the patient can interact without fear of embarrassment, correcting his or her interpretive mode and decreasing anxiety that these situations create. This is why most treatment programs include "tasks" for which the patient has to make their own coping exercise or exposure, according to the plans made in the session. Other methods, such as relaxation techniques also can be implemented to help those affected to improve control of their actions and reactions (Brady & Bowd, 2005).

There are proven drugs to treat this disorder. These so-called selective reuptake inhibitors of serotonin or SSRIs are the drugs of choice for this disorder at present, because of its proven effectiveness and present fewer adverse effects compared to other medications. The high potency benzodiazepines, such as clonazepam may be used when it is critical to the rapid control of symptoms (Park & Lee, 2005). In patients whose anxiety is caused by situations of predictable performance, such as speaking in front of an audience, can prescribe some medication such as beta-blockers before facing an undesired event to control only the somatic symptoms of anxiety, such as palpitations or tachycardia.

Post-traumatic stress disorder (PTSD). Traumatic stress syndrome is a psychiatric disorder that occurs in people who have experienced a dramatic episode in his or her life i.e., war, kidnapping, violent death in the family, horrific accident or sport related injury. Frequent nightmares or a similar environment that recall the tragic experience lived in the past are triggers (Stewart et al., 2007). Within the post-traumatic stress syndrome, experts distinguish between acute type, which occurs during the first month to three months after the trauma, and the latent type that can appear at least six months from the triggering event (Wilson & Keane, 2004).

In some cases, the onset of symptoms may occur in later decades. The most important characteristics of these factors include the remembrance of the trauma (flashbacks), nightmares or instant involuntary memories anytime of the day. In general, anything that can be related to the trauma will result in feeling psychologically distant, numb and paralyzed by any normal emotional experience. Symptoms last at least a month and affect the patient's ability to resume his or her normal life at home and at work or in social situations (Wilson et al., 2009). No matter how much time has passed since the trauma occurred, PTSD may appear years later.

Treatment. The recovery is long term, which explains the high degree of abandonment of therapy. The treatment is based on a combination of drugs and psychotherapy. The drugs used are directed to the various symptoms of the syndrome, considering the defendants. Medications are often prescribed antidepressants and anxiolytics (Brady & Bowd, 2005). However, research has proven the use of biofeedback to have positive outcomes for recovery. The aim is developing relaxation techniques, like learning to breathe correctly to a crisis caused by the syndrome or an induced adverse stimulus. The utility of EEG feedback or neurofeedback in the resolution of PTSD has successfully been established in research going back more than

a decade (Tan et al., 2011).

In addition and contrary to popular belief, the severity of the syndrome does not depend on the nature of the trauma that triggers it (Park & Lee, 2005). The reaction to a harsh and unusual situation depends on the sensitivity of the affected people and their resources to cope with trauma (Lande et al., 2010). In part this is determined by the genetic characteristics of each, but also influences the personality and the specific life situation (Brady & Bowd, 2005). It can develop at any age, but is usually more common among young people, perhaps because they are more likely to be exposed to trauma triggers. It is also more common in those socially isolated individuals, which can be an outcome to concussion recovery (Kontos et al., 2012).

Theoretical Foundation – Sport Anxiety Theories

There are several theories that have examined the anxiety-performance relationship. For the purpose of the research the catastrophe model will be the focus to potentially assist in understanding ways the athletes may be experiencing anxiety returning from a concussion. Catastrophe model of anxiety includes four key relationships between cognitive anxiety, physiological arousal and performance (Hardy, 1996). Because of these specific relationships the catastrophe model was a good fit to examine.

Catastrophe theory. Hardy (1987) suggests that the stress and anxiety will influence performance and each athlete will respond in a unique way to competitive anxiety. Performance will be affected in a unique way causing a positive and negative psychological reaction. Cognitive anxiety (worry) has a positive linear relationship with performance when physiological arousal is low. Cognitive anxiety will also have a negative relationship with performance when physiological arousal is high (Krane,

1992). When cognitive anxiety is low, physiological arousal has a classic inverted U-shaped relationship with performance (Hardy & Parfitt, 1991). When cognitive anxiety is high, increased levels of physiological arousal lead to a catastrophic drop in athletic performance.

Furthermore, once this catastrophic drop in performance has occurred, a large reduction in physiological arousal is required to bring performance back to a higher level (Hardy & Parfutt, 1991). Thus, prior to the performance, an important mental task for the athlete is to achieve a mental state where physiological arousal is at its optimal, rather moderate level, without worrisome thoughts. Usually, this means that physiological arousal is maintained by optimal warm-up and behavioral and mental precompetitive routines. Where as, worry thoughts are avoided by concentrating on personal challenge and excitement (Hardy, 1996)

The interaction between the two types of anxiety explains why the anxiety state may vary, both between individuals (the characteristic of anxiety may be different in the same situation), and individually (the same person experiences anxiety in a situation, but not another). As for trait anxiety, it should be assumed that individuality varies little, and because of its influence, differences in state anxiety between individuals should remain largely stable (relative consistency). Finally, Hackfort and Spielberger (1989) posit that, if high trait anxiety, a faster increase in anxiety-state occurs.

Edwards and Hardy (1996) extended Martens et al.'s (1990) theory by developing the Catastrophe Model. This model encourages high cognitive anxiety combined with low somatic anxiety. It is associated with better performance and that the greater a player's self-confidence, the lower the intensity of a person's anxiety

symptoms. The researchers also suggest that self-confidence may be a more important predictor of performance than cognitive and somatic anxiety levels. The level of self-confidence, however, does not have an effect on the intensity of anxiety symptoms.

Hardy (1996) continued the anxiety-performance research by developing the Butterfly Catastrophe Model. This model states that, if an athlete is confident, he/she will be able to tolerate higher levels of somatic anxiety before experiencing any decrease in performance. After gathering the qualitative data it may be concluded that the biofeedback training was able to provide tools to maintain confidence so that they were able to return to sport. These two models provide the opportunity to see how important learning to regain and maintain confidence is when returning to sport and may have the same effect outside of sport.

Anxiety, confidence & the effect on sports performance. It is known that in sport psychological influences such as motivation, anxiety and confidence can influence performance outcomes positively or negatively (Park & Lee, 2005). Understanding and manipulating these variables for competitive results in sports is critical to the success of an athlete. The results of experimental studies have suggested that anxiety-sensitive participants show a strong reduction in athletic performance during high-pressure situation (Park & Lee, 2005). According to research, the effects of anxiety and distraction and interference can explain a significant reduction in performance. However, an increase in confidence can contribute to positive performance outcomes (Vealey, 2009). The best way to assess confidence in athletes is by having a sport psychologist conduct interpersonal discussion and observation of athletes' behavior (Vealey, 2009).

Rationale

Concussion has had many definitions and has been treated with many different methods over the years, creating a variety of protocols with diverse characteristics associated with the recovery process. For the purposes of this research, concussion and the cause will be defined as a mild traumatic brain injury that can affect how the brain normally functions (Thompson & Thompson, 2006). Concussions can be caused by a direct hit to the head or an indirect hit to another area of the body that causes a shearing or a rotational force to the brain (Blume & Hawash, 2012). The result from sustaining a concussion can lead to an individual experiencing physical, cognitive and behavioral signs and symptoms (Halstead & Walter, 2010). When the athletes feel challenged to focus and concentrate properly in competition, the brain releases chemicals i.e., neurotransmitters, that gives them a feeling of anxiety and stress. Having too many worrying thoughts increases these chemicals therefore increasing heart rate and perspiration, affecting concentration and tightening muscles resulting in negative performance.

When applied, biofeedback training involves the systematic training of a participant in controlling their anatomic responses with the use of biofeedback measurement tools in relation to a certain environment. In this case the youth sporting environment (Blumenstein, Bar-Eli, & Tenebaum, 2002). The intuitive information that biofeedback can provide about brain activity and its relationship regarding psychological factors, could prove essential to an athlete's psychological recovery from sustaining a concussion.

There are many functions of biofeedback that contribute to the overall functionality of the technology. The biofeedback technology allows for bodily

measurements of blood pressure, breathing, heart rate, muscle tension, skin conductivity of electricity and skin temperature. Biofeedback also aims to teach the participant how to control and change ones bodily functions. The goal is to feel increased relaxation or the ability to cause specific muscle relation processes (Blumenstein, Bar-Eli, & Tenebaum, 2002). This process contributes to the treatment of conditions; including, stress, fear, tension and anxiety. Each component of biofeedback plays a critical role of the rehabilitation process.

Furthermore, research has shown that stress and anxiety are psychological setbacks that can be induced after receiving a concussion (Bloom et al., 2004). This research has provided positive results when practicing respiration and heart rate variability intervention training on youth athletes who are experiencing severe cases of stress and anxiety related to performance (Nolan et al., 2005). Respiration is the act or process of inhaling and exhaling; breathing. Reaching this goal can be aided by the breathing tool modalities provided with the biofeedback software. An important aspect to acknowledge when discussing respiration is the mind and body functioning as a single unit (Solms & Turnbull, 2010).

Heart rate variability refers to the waveform of beat to beat changes in the duration of heart rate intervals (Lagos et al., 2008). Heart rate variability in biofeedback is a relatively new approach for assisting athletes in regulating competitive stress and anxiety. Early results suggest that heart rate variability biofeedback intervention training may help the athlete cope with the stress of competition and/or improve neuromuscular function (Lagos et al., 2008). Emotions and thoughts affect the body and those changes affect thoughts and emotions. Experiencing a concussion has a profound impact due the great changes that can take place throughout the body after incurring one. The body's vital systems (e.g., cardiovascular, respiratory, nervous, etc.)

are also interconnected. A change in any one system may disrupt another system. For example, an altering within the mind because of a concussion could have a direct effect on respiratory patterns. In turn, it would also impact the person's experience of relaxation, anxiety, stress and fear (Solms & Turnbull, 2010).

Research has proven that bio and neuro-feedback increases that chance to alter the plasticity of the brain network linked to the disorder (Nauert, 2013). Furthermore, during the intervention, having the individual control their brain activity may be learned through a brain-computer program. This allows for the individual to see in real time brain activation on a computer monitor. The important connections within the body provide creditable grounds to research. They provide in greater depth the advantages respiratory training will have on psychological concussion recovery moving forward. The research will focus on concussions with regards to technology that could assist physicians, trainers, sport psychologist, coaches, youth athletes and parents with psychological concussion management moving forward.

Given the lack of research exploring sports related concussions and the psychological affects returning to play from a concussion, the current research question is: could a biofeedback intervention help athletes who are returning to play after sustaining a concussion? The hypothesis is that a biofeedback intervention will assist in psychological recovery after sustaining a concussion. More specially, it is expected that training to control the four modalities will develop tools to control physiology. This may have a positive effect on emotions, thinking and feeling which could result in positive behavior and cognitive outcomes.

Chapter 3 : Methods

Participants

The participants involved in the research were a purposeful sample of five male and one female hockey player between the ages of 15 and 28, totaling six athletes. All participants played competitive organized hockey in the province of Manitoba. Hockey was selected as the sport has shown to have high rates of concussion injury (Cusimano et al., 2009). Participants were identified as having at least one medically documented concussion. For the purpose of the study, all participants were previously cleared to return to play by a trained medical professional. This ensured that every participant was treated and medically cleared under consistent procedures and protocol. The lead researcher, via phone or email, contacted the participants identified as candidates for the intervention and participation in the research.

Procedure

The project received human ethics approval on April 20, 2015 by the Education/Nursing Research Ethics Board at the University of Manitoba. Recruitment took place during the months of May to August 2015. Recruitment was done through radio appearances, word of mouth, posters displayed at University of Manitoba, local hockey community centers, high schools and a social media campaign directing an individual to a landing webpage outlining the study. Data collection was conducted during a ten-week intervention during the months of September to November 2015.

The lead researcher conducted the biofeedback intervention training sessions for each athlete participating in the research. However, scheduling was dependent on participant availability. The protocol and procedures the researcher followed were

exactly the same for each session. The intervention started with a pre-focus group (see Appendix D). The focus groups were split into two groups due to scheduling. Step two had each participant participating in the Biofeedback Short Stress Test (Wilson, 2006). This is a three step process, ten minutes in length, to gather a physiological baseline of each athlete participating.

First, the participant's eyes were closed for sixty seconds with the sole focus of breathing at six breathes per minute. The applied aversive stimulus was a video of body contact in hockey causing a concussion. The video was used to induce an increase in physiological responses. The physiological responses that were tested and analyzed were muscle tension, respiration rate, heart rate, and skin conductance. Lastly the participant's eyes were open for two minutes during the recovery phase with the sole focus of bringing breathing back at six breaths per minute. The objective was to discover if there have been any positive changes to physiological baseline measure from the Biofeedback Short Stress Test. That is through the use of the respiration intervention training over the period of the intervention.

At the completion of each short stress test, a standardized assessment of physiological parameters was measured. The participant's eyes were closed for ninety seconds with the sole focus on trying to breath at six breaths per minute. Then the participant eyes were open for two minutes with the sole focus on trying to breath at a rate of six breaths per minute. This provided a mean for each physiological measurement (i.e., muscle tension, respiration rate, heart rate and skin conductance) measurement of the participant's recovery to allow for a quantitative analysis of each respiration session.

The initial session served as a physiological baseline measure where parameters

including sweat conductance, heart rate, muscle tension, skin temperature, and rate of respiration were measured. The short stress test required that all modalities be measured and recorded for the short stress test to be performed effectively. For the purpose of the research study, muscle tension, skin conductance, heart rate and respiratory rate were the focus for analyzing outcome measures.

For step three, the participants participated in the biofeedback intervention consisting of four respiration-training sessions lasting twenty minutes in length. The intervention allowed the participant to receive immediate feedback (audio and visual) that indicated the correct abdominal and thoracic amplitude, muscle tension and skin conductance related to breathing. The breathing practice trained the participant to inhale and exhale at six breaths per minute.

For step four, participants went through the Short Biofeedback Stress Test (Wilson, 2006) again, lasting ten minutes. Step five is a repeat protocol of procedures for the respiratory training performed in step three. Step six was the final Biofeedback Short Stress Test, which is the same Short Biofeedback Stress Test performed in step two and four. Finally, in step seven participants participated in the post focus group session (see Appendix E).

Measures

A mixed methods approach was used for this study. For quantitative methods of biofeedback, four modalities were measured and analyzed for the purpose of the intended research. These modalities included; muscle tension, heart rate, respiration rate and skin conductance. In addition, a qualitative component was part of the intervention consisting of focus groups.

Electromyography (EMG) or muscle tension. Muscle tension is the most frequently used biofeedback method. This biofeedback setup uses an EMG sensor to represent muscle tension as a series of visual or audio indicators and allows the participant to train the body to adjust muscle tension. Muscle tension provided a valuable outcome measure, which indicated that individuals were experiencing, stress, anxiety, chronic pain and headaches when exposed to adverse stimuli (Wilson, 2006). The participants were able to use the immediate feedback to learn how to control muscle tension and bring it below 3.5 microvolts. Elevated or overreaction of muscle tension showing greater than six microvolts indicated a reaction to the stressor (Wilson, 2006). Using electromyography (EMG) sensors located on the participants left and right shoulders the muscle tension was measured in microvolts allowing the participants the ability to relax their muscle tension.

Heart rate. The heart rate was measured using a blood volume pulse located on the participant's non-dominant thumb. Increases in heart rate are associated with emotional arousal, such as being angry or fearful. Decreases in heart rate are associated with increased relaxation. Heart rate (beats/min) provides an important baseline measures for analyzing responses to stress. The normal resting baseline for an average person is 70-80 beats/min. (Wilson, 2006). For athletes, the average resting heart rate is 45-60 beats/min (Wilson, 2006). A normal reaction to a stressor shows an increase of up to 20 beats per min. An elevated or overreaction to a stressor would indicate results greater than 20 beats per min. The intended end result of training one's heart rate is to be able return to baseline levels during the recovery period from a stressor.

Respiration rate. Respiration rate was measured using two-respiration sensor that went around the chest and abdomen monitoring expansion and contraction and outputs the respiration waveform. This differentiates correct breathing from

problematic breathing practices. Breath control training may be used to treat panic attacks, and a variety of stress-related conditions. Respiration rate (breaths/min) provided a valuable measure as to how the participant trained his/her breathing as a calming response to the stressor. Normal resting baseline is 12-15 breaths/min. Athletes have shown to have lower breaths/min of 8-12 breaths/min (Edmonds et al., 2009). A normal reaction to a stressor is an increase of up to 20 breaths per min. Overreaction would be greater than 20 breaths per min. A normal recovery from a stressor indicated a return to baseline measures during the recovery. A very low respiration rate in baseline and recovery shows that the individual does have a stronger awareness of themselves and how their body is reacting.

Skin conductance. Skin conductance was measured using skin conductance sensor located on the index and ring finger on the participant's non-dominant hand. Sensors on the fingers monitor perspiration or sweating. Research has shown that skin conductance may be used in the treatment of anxiety, fears, stress and sleep problems (Thompson & Thompson, 2006). Skin conductance is based in the primitive 'fight or flight' response, whereby the body prepares itself for the exertion needed to deal with a perceived threat by increasing sweat activity to induce a cooling effect (Venables & Mitchell, 1996). This response occurs frequently, at low levels, as the mind experiences thoughts and emotion. Sensitive responses to thoughts are only found at two places on the body, the hand and foot. The unit for skin conductance was measured in microSiemens (Venables & Mitchell, 1996). It was measured from 0-10 (low to high). Ideal resting baseline is between 0-5 is normal, however some individuals can have resting baselines from 5-10 (Wilson, 2006). Normal reaction to a stressor is an increase in value less than 100% the baseline measurements. Overreaction to a stimulus yields increases of greater than 100%. Normal recovery from a stressor is a decrease in

value back to the original baseline. A consistent increase in skin conductance over the assessment indicates increased stress without recovery or participant is warming (i.e., body temperature increases). Consistent decreases in skin conductance over the assessment meant relaxation responses, or participant is getting cold. Self-calming by physical or cognitive means tends to lower skin conductance, while negative emotions such as fear, worry, or anger usually raise it. Any disorder, which would benefit from emotional calming, may respond to skin conductance biofeedback, provided the learner is able to generalize from the feedback situation to real life.

Qualitative methods

Focus Groups. Focus groups were conducted at the start and end of the biofeedback respiration intervention training. Focus groups are a form of group interviews that capitalize on communication between research participants in order to generate data (Rabiee, 2004). The purpose of conducting a focus group is to listen and gather information regarding the topic of research (Patton, 2002). In particular the focus groups assisted the researcher to better understand how the participant's feel or think about the psychological setbacks related to concussions and feelings associated to anxiety and confidence. The focus group assisted in promoting self-disclosure among the participants with regards to the psychological effects sustained from receiving a concussion. The ability to share life experiences with similar peer groups has a profound positive effect on confidence. The first session provided qualitative information about the similarities and struggles with psychological setbacks that each participant dealt with on a daily basis with managing their concussion recovery. The post focus group sessions provided qualitative information to explain any progress relating to anxiety and other symptoms and an increase in confidence. All focus group session were recorded to allow the research to revert back to the recording and take

field notes with regard to spoken content and participants' demeanor. The lead researcher also took field notes with a pen and paper during the focus groups sessions. The participants were randomly divided into two groups of three for their pre and post focus group session. The focus group session, lasted from 45 to 60 minutes in length. All focus group took place in a private room located at the Active Living Centre at the University of Manitoba.

Data Analysis

Quantitative data. The sets of data analyzed over the period of the research were the pre, mid and post short stress tests while exposed to the adverse stimulus and the eyes open and eyes closed recovery period to the adverse stimulus. First, the pre Biofeedback (Short Stress Test), mid (Short Stress Test) and post (Short Stress Test) measurements during exposure to the aversive stimulus (watching a hockey video hits causing a concussion for two minutes) were collected. The mean muscle tension, respiration rate, heart rate and skin conductance during each phase was reported. The Biofeedback Short Stress Test (i.e., pre, middle and post results and the eyes open/eyes closed pre, mid post results from the baseline measurements) was analyzed using repeated measures analysis of variance (ANOVA). A-repeated-measures-ANOVA is a parametric statistical technique used to determine whether significance exists among means of three or more sets of data (Vincent, 1999). When there is only one group of subjects but they are measured more than once, the data sets are dependent and the subjects serve as their own control (Vincent, 1999). The software used for running the quantitative stats was SPSS 22.0. For the purpose of the research, the p-value of less then 0.05 was accepted as significant.

Qualitative data. The data analysis was conducted after the final focus group

session. Focus groups were transcribed verbatim using a phenomenological approach to qualitative research. Phenomenology is a qualitative approach to research that aims to gather "a deeper understanding of the nature or meaning of our everyday experiences" (Patton, 2002, p. 104). It consists of "what" the participant experiences and "how" they experience it (Creswell, 2013). Further, phenomenological research describes the meaning for several individuals of their lived experiences of a phenomenon (i.e., youth athlete concussion). In addition, it explores how individuals make sense of experiences and how those experiences are transformed into consciousness.

This approach required capturing and describing how the participants experience, perceive, feel about, judge, and make sense of some phenomenon (Patton, 2002). To gather data, focus groups with individuals who have directly experienced the phenomenon of interest were conducted (Patton, 2002). Using this approach, the researcher used the views and experiences of the participants themselves to answer the research question. The study followed Colaizzi (1978) seven steps to process interpretive qualitative data.

The first task of the researcher was to read the participants narratives, to acquire a feeling for their ideas in order to understand them fully. The next step, extracting significant statements, required the researcher to identify key words and sentences relating to the phenomenon under study. The researcher then formulated the meanings for each of these significant statements. This process was repeated across participants' answers to the questions and recurrent meaningful themes were clustered. Returning the scripts to the participants before the data analysis to check interpretation was valid with the researcher's interpretation of the focus group data collection.

The participants were given two weeks to return the information provided. The researcher integrated the resulting themes into a rich description of the phenomenon under study. The next step was reducing these themes to an essential structure that offers an explanation of the psychological setbacks sustained from receiving a concussion and the effects of the biofeedback intervention. The qualitative data was coded and themed into key areas relating the psychological setbacks from sustaining and concussion and the effects of the biofeedback intervention, the information was provided to the participants for additional member checking and feedback.

The software used for accomplishing the qualitative data was NVivo 10. NVivo is software that supports qualitative and mixed methods research and is designed to help organize, analyze and find insights in unstructured or qualitative data (i.e., interviews, open-ended survey responses, articles, social media and web content).

Chapter 4 : Quantitative Results

The biofeedback results were calculated in SPSS using a repeated measures analysis of variance (ANOVA) design (see Table 1). A repeated measure ANOVA is also referred to as within-subjects ANOVA. This implies that the nature of the repeated measures ANOVA detects any overall difference between related means. The analysis of data using a repeated measures ANOVA explored changes of heart rate (HR), skin conductance (SD), muscle tension (MT) and respiration rate (RR) means scores over the three time points (pre, mid and post biofeedback stress tests). The dependent variables were the stress test. The independent variable was the time points (pre, mid & post). The research investigated the effect of a three month biofeedback breathing training programmed on the four modalities (HR, SD, MT & RR) at three separate time points (pre, mid & post intervention), which would allow for the development of a time-course for the exercise effect. For example, when measuring changes in heart rate due to a biofeedback-training program, the independent variable is time making each a specific time point. Hence, for the exercise-training study, there were three time points and each time-point is a level of the independent variable.

Results form the biofeedback stress tests indicated that all participants ($N = 6$) used the breathing technique (six breaths per minute) to control their heart rate during the stress test one to stress test three. The biofeedback training consisted of ten training session between the first stress test and the last stress test. A repeated measures ANOVA with time as the independent variable was used in order to determine whether there was an intervention effect for controlling the four modalities from stress test one to stress test three. Results indicated that heart rate significantly decreased over the three time points (HR; F (1, 5) = 22.249, p = .005) (see Figure 1). A repeated

measures ANOVA was also conducted on the additional three modalities testing physiological control in order to determine if there was a significant decrease from stress test one to three. While the participants indicated feeling a sense of control over muscle tension, skin conductance and respiration rate over the intervention and during the stress tests produced no significant effect. A pairwise comparison was run with the heart rate stress data and a post-hoc testing measure.

Chapter 5 : Qualitative Results

Pre Focus Groups

The pre focus groups provided a platform for the participants to express the psychological challenges they have been faced with since sustaining a concussion. The main themes include psychological challenges returning to sport, psychological challenges in personal life, and challenges with self (see Appendix F).

Psychological challenges returning to sport

One of the main themes of the research was the importance of understanding the difficulties returning to sport after experiencing a concussion from a psychological perspective. The participants in the focus groups discussed four distinct difficulties returning to sport: fear of re-injury, low self-confidence, emotional control and lack of focus.

Fear of injury. Through the focus groups and field notes, it was determined that fear played a major role when returning to sport, school and social life. Fear of re-injury was a main concern when the participant returned to play because of the personal struggle from recovering from the previous concussion. John noted fear before, during and after the game:

> Before each game I have an uneasy feeling always, I can't sit still. During the game I am consistently thinking 'I don't want to get hit', 'when is this game going to end'. After most games I would experience fear that I had a concussion again if I hit my head during the game.

Fear also induced negative thoughts, which made the participants feel less confident in

their abilities to perform at the same level as pre-concussion. As stated by Sam;

> I didn't feel healed when I showed up at the rink due to my fear. I wanted to stay away and I didn't want to be there because all I could think about was my head and not playing the game to my abilities.

Fear was a common link that resulted in increased anxiety and a lack of confidence for the participants after a concussion.

Low self-confidence. When returning to sport after a concussion, confidence decreased the participants' belief in their ability to complete a skill, play or task required for the particular sport. Low confidence allowed the athlete to experience doubts that had an impact on their ability to perform. This created a major problem when talking about concussion because the athlete may have been indecisive or not fully committed to their decision making process which could expose them to the potential of receiving a second or third concussion. Alex stated:

> Receiving a concussion has destroyed my confidence. I know who I want to be on the ice and it's not what I am. I like to hit and play in the corners and now I have no confidence to play that style of game anymore. I feel completely out of place when I step on the ice. It's frustrating because on the outside teammates and coaches see me as healthy which effects my confidence ever more.

Struggling to regain confidence was a major hurdle to overcome due to the physical nature of the sport (i.e., potential to get hit in the head on every shift) combined with the fear of potentially receiving another concussion and never being able to play the game with friends and teammates again. The result of a decrease in confidence leads to

the next theme of negative emotional control.

Emotional control. Controlling emotions when returning to sport after receiving a concussion can prove to be very difficult. This was a sub-theme that all participants discussed. As an example, Bob expressed that:

> I felt stressed all the time during a game or practice since returning to hockey. This created a whirlwind of negative emotions for me with the most notable one being my temper. I couldn't control getting very frustrated that I couldn't play the way I wanted to.

Alex agreed with Bob by stating,

> I found myself lashing out at my teammates, coaches or parents during or after the game if they said something to me I didn't agree with. This was not the person, teammate or son I was before my concussion or how I was accustomed to reacting to situations involving feedback about my play.

The participants in the focus groups all shared this common theme of struggling to control their emotions and behavior.

Difficulties with Focus and Concentration. Participants expressed the difficulties they were having with focus and concentration. Kelly mentioned, "I was too anxious about injuring myself again that I couldn't focus properly on my play during the game, which has lead me to get anxiety before". The inability to have control of focus and concentration contributed to affecting fear, confidence, and emotional control resulting in psychological setbacks that were experienced post-concussion. Rob mentioned:

> I've been playing hockey for fifteen years and know what I am supposed to do on the ice but since returning to hockey, I can only focus and concentrate on all

> my fears pertaining to having a concussion or experiencing another one.

When the athletes felt frustrated and they could not focus and concentrate properly in competition, the brain released chemical that gave them a feeling of anxiety and stress. For the participants, the inability to focus on the right positive things at the right time creates extra pressure that magnifies the psychological obstacles. As discussed in the review of literature, areas of psychological challenges play a major role in negatively effecting areas that show an increase in physiological measurements, when returning to sport.

Psychological challenges in personal life

The qualitative results from the focus groups indicated that individuals experiencing psychological setbacks do not have the tools to cope with their new everyday realities. The participants in the focus groups created distinct themes pertaining to anxiety and the difficulties returning to their new everyday reality due to their concussion which are: diminished self-control, self-medicated or the use of prescription drugs, low self-esteem, challenges with self and social anxiety.

Social Anxiety. Bob shared situations that have changed since receiving a concussion, “I now hate big crowds; I feel completely out of place, feel crazy and stressed all the time while at an event. It even is so bad now; I go to my truck and just scream.” Sam says,

> I now get so nervous to meet people and I used to love meeting new people. If I feel like I will be the first one at an event, I will just wait in my car or outside until I see one of my friends arrive, just so I am not put in a situation to meet new people, it is so strange.

What was interesting about this common theme between the participants was that social anxiety might be attributed to a health condition that draws attention i.e., facial or body disfigurement, Parkinson's disease and other health conditions. However, a concussion has no visual nature to the appearance. The participants had no visible health condition that drew attention making experiencing social anxiety harder psychology because only the individual could notice the effects the concussion had created. That is why understanding the changes on health condition at the psychological level can play a key role to give this invisible injury an identity and a foundation to improve on. Bob states,

> I was always used to being around my friends and teammates then after the concussion I was alone all the time. Once I was cleared to return, I would experience anxiety every time I was back with my friends or teammates. I ended up not going to things and stayed in my room.

Sam followed up by saying,

> I felt the same way with my family. I wouldn't want to be around them after my concussion. Anything they did would drive me crazy or I'd just flip out if something went wrong with the plan.

Social anxiety played a major role in affecting the individual ability to return to a normal way of life.

Family. Members of the focus group noted that changes had taken place in his/her relationships with family after concussion injuries. Alex noted,

My dad told me that since my concussion my best defense is my offense, I respond to most things now with my family with a very snappy attitude. While before my injury

my relationship with my family was good.

Bob agreed with Alex by stating,

> Before it was just my dad I would argue with, now I find myself arguing with everyone in my family and it is taking a toll on my relationship with every one of them, it is a horrible feeling.

John also shared the similar feelings, "Before my concussion I loved being around my family, now I would rather stay in my room and even have taken a job out of town just to be away from them."

Teammates. The members of the focus group also noted they had difficulty with teammates post-concussion. Kelly expressed that,

> …being around my teammates was really hard for me because I could feel that they thought I was okay but inside I was a mess. I hated going to watch my team play because it made me feel really depressed I wasn't out there with them and having fun together before and after games. I felt that my friends and teammates didn't understand me or what I was going through which made me have no confidence. Bob also noted,
>
> I ended up showing up to practice or games in a sling saying I had a shoulder injury because I felt it was the only way my teammates would believe me that I was actually hurt, it really sucked faking an injury I didn't have.

Challenges with self

Understanding the changes to the self that happens after receiving a concussion can be very challenging. During the focus groups, two key aspects about the self

became main sub-themes in the data: low self-esteem and diminished self-control.

Low self-esteem. Low self-esteem became evident during the pre-focus group sessions. Due to being socially withdrawn, constantly anxious, feeling sad and depressed, inability to communicate effectively, insecure about the concussion injury, and fears that they might never get better were all expressed throughout the focus group. Rob states:

> What really affected my self-confidence after having a concussion was my role within the team and social group changed overnight. I went from being a leader on my team, to not having a voice as I spend a lot of time away from the team during my recovery. Also within my social group I wasn't included as often because I spent so my time alone and ended up missing out on a lot.

Kelly talked to this point by saying:

> My self-hating, because I couldn't ever seem to get better, has taken a greater toll on my recovery then the injury itself. Going to the doctor actually made me hate myself more because one doctor I went to told me I didn't have a concussion anymore, I had depression.

Alex followed up with, "I was prescribed medication for depression and anxiety when all I wanted was to be treated for my concussion."

Diminished self-control. Every participant in the focus group expressed diminished self-control. In situations that never bothered them, they now find themselves having no self-control. John says, "My temper is out of control, I was a really laid back guy before my concussion, now everything seems to bother me." Sam

went further, saying, “I have a hard time driving anywhere without getting road rage, especially with family in the car, my fist are even indented into my steering wheel now.” Bob also agreed with Sam regarding uncontrollable road rage. The participants also expressed a mutual feeling, that if the plan changes or they lose control of the situation, their temper is easily put over the edge. Bob stated:

> After my concussion I needed to be in control all the time, I would flip out if something goes wrong with the plan. Before my injury I didn’t care to be in control and thought as a pretty easygoing person.

The participants expressed using “happy” pills, alcohol and sleeping pills. John said, “I take four types of medication now for depression and anxiety, I never needed to take any medication before my concussion.” Bob talked about the use of “happy” pills:

> I was given these “happy’ pills from a friend who was worried and said these would make me feel better, I ended up taking them every day for a year and finally stopped because I had no idea what they were.

The participants could be taking action into their own hands because they are not receiving much direction on how to treat their psychological side effects from the concussion. The pre focus groups outlined many areas of concern that the participants are dealing with every day in their life.

Post Focus Groups

The post focus groups provided valuable data indicating a significant improvement after the biofeedback training with overcoming fear, regaining confidence, enhanced emotional control and improved focus and concentration (see Appendix G).

Positive psychological changes returning to sport

Overcome fear. Experiencing fear was a main setback for all participants when returning to sport. Physiological changes that can happen when fear is experience are, but not limited to, tense muscles, increased heart rate, faster breathing rate and increased perspiration. The objective of the biofeedback training was to first have the participants watch two minutes of concussion causing hits (stress test to an adverse stimulus).

Where the participants were able to see in real time what parts of their psychology were affected negatively. With these four physiological modalities being the focus of the biofeedback training, the participants feedback showed a better control over these modalities in real time. Bob stated:

> On the way to the game and during the game all I could think about was sustaining another concussion. When I applied my breathing training, I was better able to focus on just playing the game I love and not feel all tense in my muscles.

Alex supported Bob statement by saying,

> Before a big game the biofeedback training helped me stay calm and relaxed and not feel anxious about receiving another concussion during the game. It really helped me think of a happy place which, I believe, reduced my fear.

Regain confidence. A participant in the research expressed having negative feelings about what they cannot do after the concussion and that it had affected their performance negatively. Kelly discussed how confidence has been regained through biofeedback training:

I feel more in tune with myself, because now I have a better understanding of how my body functioning works, which has allowed me to be confident again with whom I am.

Bob also mentioned:

> Before games I would feel very anxious, but now on the way to games and calm myself with the breathing pacer and focus on that for ten minutes. When I get to the rink, I feel completely relaxed and my performance has improved, which has made me feel confident again to play hockey.

Essentially, the participants may reach a higher level of self-efficacy and confidence as a result.

Enhanced emotional control. The participants were able to see how there physiology reacts (i.e. muscle tension, heart rate, skin conductance and respiration rate) to an adverse stimulus (i.e. watching two minutes of concussion causing hits). The participant was able to understand which physiological functions were affected. Rob stated:

> Before games and during games after my concussion, I would feel like screaming or extremely frustrated where I would want to break something because just putting on my equipment now has become difficult, never mind trying to keep in control during a game. Since the biofeedback training, I use the breathing techniques before the game and in the dressing room while getting ready, because I now know what my body is doing and how it reacts to situations. It's been amazing for me to stay in control of my emotions and have fun playing hockey again.

Alex agreed with Rob saying:

> Nothing that I have tried during my recovery has been this helpful for me to feel like me again. I use the breathing techniques whenever I need to relax before practice or games, I would feel very anxious before games and my performance has now returned to the productivity I had pre concussion. It is a great feeling being more in tune with myself.

Improved focus and concentration. During the biofeedback training there is a big emphasis on the ability to focus and concentrate so that the participants controls and maintains positive physiological functioning with in the controlled thresholds. Sam says:

> When I felt myself losing my focus and concentration before a big game, I would reset my breathing by focusing strictly on pacing my breathing at six breaths per minute. It immediately helped with concentrating on what I needed to do.

The participants also described that when a headache would come on or during the game it was very hard to maintain focus and concentration. Alex explained that he used biofeedback for his headache management stating. “The headaches coming and going really bothered me because I had no control and didn’t know when or why they would happen. I used the biofeedback training to learn how to relax my muscle in my shoulders, which allowed my headaches to decrease. I am using these techniques all the time now.”

Due to the fact that no two concussions are alike, the psychological symptoms that each participant may face can be very different. The post focus group qualitative data provided positive results with biofeedback training for individuals experiencing psychological setbacks.

Positive changes in personal lives

The post focus groups qualitative data looking at the positive changes outside of sport indicated a significant improvement in social dynamic, emotional control, focus and concentration, school, work and family relationships improved.

Overcoming social anxiety. Indicated in the pre focus groups, social anxiety was a major concern during the recovery of a concussion. After the biofeedback training the participants had this to say about integrating back within their peer groups, school and work.

Bob mentions:

> Before I would wait in my car not to be the first person there, or call to make sure my friends were already there, but not if I am feeling anxious before getting together with friends I spend four or five minutes breathing and I totally feel relaxed and calm now about hanging with my friends.

Sam shares similar feelings:

> Before the biofeedback training all I wanted to do was be by myself at home, now that thought really bothers me, I have changed my relationship with my girlfriend and friends were I am now calling them to do stuff, even go to the bar which I hated to go after my concussion.

This is important with social anxiety as it shows the potential for psychological recovery after sustaining a concussion. Bob states that,

> The focus groups and biofeedback training were very therapeutic to overcome my anxiety with being around my peers. It was a huge weight off my shoulders

that I could be myself again interacting with my friends.

Positive emotional control. Controlling emotions when returning to sport, deals more with the environment and the self. Controlling emotions outside of sport tend to deal more with family and friend relationships. The participants discussed the difficulties controlling emotions with family members and friends and how those relationships have returned to normal with positive communication.

***Family*.** Family dinners or gatherings were a challenge for a couple of participants.

Alex mentions:

> Family dinners became especially difficult. They would most likely end in yelling which led me to resort to eating dinner in my room alone. Since the biofeedback training, I am eating again with my family having positive communication. I like that it has gone back to how it was before my concussion. I have incorporated the training into my everyday life.

Sam expressed similar feelings and the improvements with emotional control:

> The best thing about the biofeedback training; it has given me the ability to find different ways of working through situations in a much more positive way. I think my family has really noticed a positive change with controlling my emotions.

Bob supports these statements by adding, “It has taken a huge weight off my shoulders being able to communicate effectively and positively with my family.

Driving with family members was a common concern expressed throughout the

> focus groups. Having family members control their driving or not being in control of driving created profound negative emotional control that was not expressed pre-concussion.

Rob expressed his concerns around driving:

> If I am in the car and not driving since my concussion, I found myself shaking uncontrollably. My mom would have to ask me to stop shaking the car. Since the biofeedback training I have developed a way to stay calm because I spend the time focusing on breathing instead of getting angry.

John shared his reaction to road rage with family members in the car, "If my family started to tell me how to drive or where to go I would start hitting the steering wheel to the point that you can see my fist engraved. I never lost my control while driving before my concussion. Now when I get into my car I spend two to three minutes breathing until I feel calm, happy and then proceed to drive. I haven't had any encounters with my fist to steering wheel post biofeedback training, which has been a great feeling."

Friends. The effects a concussion had with controlling emotions when with friends was proven to be difficult from the participant's personal accounts. Maintaining positive communication and a healthy relationship with friends proved to be a great challenge and concern. Alex says:

I always like being around my friends because friends are important to me, and since the concussion I found myself arguing all the time and for reasons that didn't make sense. I started to distance myself, not contact friends to a point where I was back in my room alone all the time. The biofeedback training has given me the confidence to

be myself again because I have a greater understanding of myself, which has been positive with my friends and not experience uncontrolled negative emotions that were affecting my long-term relationships. Biofeedback training has really helped me through these tough times.

Kelly mentioned that after the concussion she was really stressed and anxious to be around her friends because, to her friends, she looked normal but inside she knew she was suffering the effects of the concussion:

> When your friends can't see your injury it makes it really hard for them to understand how injured you really are. I didn't know how to conduct myself with my friends after my concussion because to them I looked fine but I wasn't myself. It made me really lose emotional control and I would go home and cry. The biofeedback has changed everything for me. I now feel heeled from the inside out and no longer feel stressed or anxious when around my friends.

Positive changes with the self

The post focus group data indicated that the biofeedback intervention allowed the participants to gain knowledge of how changes in physiology had a strong correlation to how they viewed themselves.

Regained self-control. The post focus group data indicated that the participants felt they regained self-control through doing the biofeedback training. Sam states:

> I struggled every day after my concussion to understand my new self and the feeling of never feeling in control, as it was really hard to look in the mirror and not recognize myself anymore. The biofeedback training gave me an insight

> into understanding myself, which has helped me with everything in my life, it is the most relaxed I have felt in my life. I will continue to practice my breathing for the rest of my life.

Bob expressed the same positive feedback,

> …being more in tuned with my body with having a greater sense of self-awareness has provided me with the knowledge to stabilize my self-control particularly when put in situations where I would lose all understanding myself.

Developing self-management tools learned through biofeedback training with respect to controlled breathing may have provided the participants struggling with psychological aspect a path to becoming the people they recognized before the concussion. John suggests:

> All the doubts about me and how I wasn't able to control myself created many depressing moments for me. However, going through the biofeedback training has changed all those feeling towards myself, it has allowed me to be the most relaxed I have been since my concussion. It has provided so many benefits in my life now, I will be using the techniques used from the biofeedback training for the rest of my life.

The participants expressed not having to be prescribed anti-depressants, anxiety medication or a substance abuse problem pre concussion. Sam states:

> I went to the doctor regarding my concussion and I left with the doctors telling me I have depression and got prescribed four different types of medications. Since going through the biofeedback intervention I know I'm

> only taking one medication and hope to be off my last one very soon.

Rob discusses how he was given “happy pills” by a friend and found himself taking them every day for over a year:

> I took these “happy pills” every morning and I didn’t even know what they were really doing. During the biofeedback training I stopped taking the pills because the biofeedback training made me feel calm, composed and confident again. I no longer feel angry all the time.

Chapter 6 : Discussion and Conclusion

The purpose of this research was to apply a biofeedback intervention with concussed athletes experiencing psychological setbacks, answering the following question: could a biofeedback intervention help athletes who are returning to play after sustaining a concussion? The study took a mixed methods approach and, in the quantitative data found one significant result. Heart rate was able to decrease from stress one to stress test three, indicating a significant change to stay in control when faced with a stressful situation. They were also able to stabilize the anxiety that they experienced in social circles and with family members. The members of the focus group stated that post biofeedback treatment they had more confidence in their abilities in sport. That it was easier for them to be comfortable with themselves especially with their teammates. Despite small significant results in the quantitative data, some valuable information was gathered through the qualitative focus groups. The results of the focus groups will be highlighted in this discussion. Through the focus groups, the participants expressed the ability to overcome fear, regain confidence, positive emotional control and the ability to focus and concentrate accordingly.

Effects of the concussion on members of the focus group

Research has demonstrated that mood swings and emotional irritability can be attributed to injuring part of the brain that controls emotions and behaviour (Bailes, 2001). The inability to focus and concentrate can also be linked to experiencing a sport related concussion (Vaschillo et al., 2006). As stated, fear and low confidence contribute and play a major role in affecting his/her ability to return to sport, which can lead to elevated negative emotions that cause a negative behavioral reaction. Emotions in sport can be described as an intense mental state that arises in the nervous system

rather than through conscious effort and, evokes either a positive or negative psychological response (Jones, Hanton & Swain, 1994). For the purpose of this research, the study focused on the negative responses to returning to sport after receiving a concussion.

Anxiety. An individual with social anxiety disorder (SAD) experiences a persistent fear of social situations (Bayer, 2007). During an individual experiencing SAD physiological modalities will be affected that have the potential of negatively effecting a situation due to the person not having the tools to manage the circumstance. For example, an individual will experience increased muscle tension, increased heart rate and sweating or increased skin conductance when experiencing social anxiety. Fear is an emotion created by a perceived threat that has happened in the past, present or future (Conroy & Elliot, 2004). In sport and with regards to concussions, the fear can be related to feeling afraid of getting physically hurt again or it can be a fear of failure due to not being able to play at a person's full potential. Fear can have a major impact on the physiological functioning (Davis & Sime, 2005).

Hillman et al. (2003) states that anxiety is the negative aspect of experiencing stress, resulting in stress that is experienced due to either fear of failure or not preforming in sport and created from the ability to not focus or concentrate properly (Bloom, 2008). Having too many worrying thoughts increases heart rate and perspiration which affects concentration and tightening muscles resulting in negative performance outcomes (Thompson and Thompson, 2006).

Social anxiety can also stem from the amount of time an individual spends alone during the recovery process (Covassin et al, 2009). All members of the focus groups explained that being away from their friends and especially teammates made it

difficult when returning to sport and social gatherings. Bob, Sam and Kelly said that it was difficult being around their friends and even their family and ended up not attending social gatherings or they would spend their time alone in their rooms or in their cars. This isolation was not understood by those around them and the lack of support made it difficult to cope with.

Family and friends. Family and friends might not understand the changes that happen after a concussion making it more difficult for the individual returning from a concussion. The importance to understanding the psychological setbacks from receiving a concussion was to look at the new challenges of integrating back into social life, school, work and family relationships. When a child experiences a concussion the effects on family can be profound (Kontos, 2003). For example, the family routine changes, there are missed days of school or practice, sudden medical crises, cancelled vacations/social events, a parent's consistent attention on the child and a change in positive communication between child and parent. Also, friendly banter with friends did not have the adverse effect on negative emotional control as it has had after the concussion. The more education provided about the psychological symptoms related to concussion, the more the injury can be made visible to family and friends (CDC, 2013).

Effects on personal confidence. Due to these circumstances, common sub themes that contribute to low self-esteem after having a concussion are social withdrawal, hostility towards family, often feeling jealous and envious of teammates, and the invisible physical symptoms. These themes may be attributed to the trauma induced when receiving a concussion (Blume, Lucas & Bell, 2011). The key factor that ties these sub themes together is the emotionally disastrous experience from receiving a concussion and through the return to play protocol. The physical invisible nature of the injury promotes self-hating because everyone sees the concussed individual as healthy

on the outside, when in fact the individual feels very physically hurt. This is a real concern as the side effects of a concussion could actually outweigh the injury itself. Low self-esteem has the potential to negatively affect the recovery process from a concussion due to many of the factors that can occur.

Effects on self-control. Self-control is the ability to control emotions and behaviour (Bandura, 1997). Controlling emotions and behaviour have proven to be a great challenge after sustaining a concussion. Losing self-control has had a profound impact on the participants in the research study. With losing self-control, it is very difficult to regain confidence during the recovery process (Bloom et al., 2004). With the loss of self-control comes self-hating, as the participant realizing their actions were completely out of line. With hatred of the self and the individual not happy with who they have become, the result was often self-medication (i.e., the use of prescription drugs). Self-medicating can be the result of experiencing psychological setbacks from a concussion (Chrisakou, 2009). This is a very dangerous endeavour as the participants are not medically trained and are not educated on the side effects. For example, participants consumed medication for untreated anxiety, depression and other mental disorders (Blume, Lucas & Bell, 2011), all of which may be linked to living with concussion.

Support for qualitative methods within concussion recovery. Allowing the participants to share their difficulties within a focus group environment provided opportunity to not feel alone and, for the first time for most of them, they had the ability to communicate these challenges that were common between participants. For example, the concussion seemed to show a negative change in family dynamic that may be attributed to the invisible nature of the injury. Participants stated that parents were lost about how best to care for their child. With more responsibilities to manage

the side effects of the injury, a perception of "faking injury" is a real issue (Makdissi et al., 2013). Family plays a critical role in supporting the concussed family member in a positive and understanding way. They have the ability to be a great asset to the medical team treating the athlete and a great support system during the recovery process. Information such as this was discussed and shared between participants and would not have surfaced if the study was purely quantitative in nature. Allowing the participants to share their difficulties within a focus group environment provided opportunity for the research to gain valuable insight.

Complications arising while returning to sport and social activities. There can be a lot of pressure to come back after a concussion because teammates see the individual as healed (i.e., no cast, sling or crutches). However, the concussed individual is suffering on the inside (Bloom, 2012). Teammates can have a negative impact on the recovery of a concussed individual (Lovell, 2003). The peer pressure from teammates to return to play can magnify the concussion recovery process by damaging self-confidence and potentially have a concussed individual fake being recovered in order to be back apart of the team and eliminate the pressure of being away from the team (Blume, Lucas & Bell, 2011).

The loss of the self can be a potential tragedy of sustaining a concussion (Maher et al., 2014). Examining the changes in oneself is seldom treated in the recovery from a concussion, yet as the data in the focus groups suggest, the loss of the self can be so profound, that if not treated, individuals may never fully recover from it. Moser & Schatz (2012), state that a concussion can strip away learning, personal identity, and personal power. Behavioural and cognitive changes can take their toll on the individual due to the negative impact these changes can have every day (McLellan & McKinlay, 2011). Focusing on low self-esteem, uncontrolled self-control and an

increased self-awareness with regards to effecting behaviour can have a profound impact on the psychological recovery from sustaining a concussion.

Being able to control their physiological responses to the adverse stimulus through biofeedback training provided confidence for the participant to stay calm and relaxed, which allowed them to play their game without concerns or thoughts triggering fear about getting injured (Guskiewicz, 2004). Being able to implement the biofeedback respiration training to reduce fear of injury with the ability to stay calm and in control of their physiology is an indicator that biofeedback training has had a positive effect on the participant psychology when recovering from a concussion (Thompson & Thompson, 2006).

Regaining confidence as expressed in the pre focus groups was a major hurdle to overcome after sustaining a concussion. Self-confidence can influence performance positively in sport when individuals are physically and mentally capable of performing the skill (Hanin, 2000). Biofeedback training has given the participants the ability to gain a new sense of inner control, which allows for a restored confidence and emotional balance. Essentially, by seeing the visual change on the screen and associating it with a more peaceful, calm internal state, the participants learn to manage stress and maintain a state of physiological coherence and balance, which has a strong correlation to maintaining confidence (Lagos et al., 2008).

Controlling emotions when returning to sport after receiving a concussion can be very difficult due to the physiological toll recovery can take (Marshall, 2005). With this understanding going into the respiration training the participant is able to train these physiological functions to stay within the threshold demands. Training these physiological functions allows the participant to stay calm and relaxed when put in

situations where stress and anxiety is induced and leads to uncontrolled emotions. The biofeedback training has given the ability to manage negative emotions and help redirect positive body and brain communication for managed emotional outcomes before and during performance (Blumenstein et al., 2002).

The post focus groups qualitative data provided positive results when examining improved focus and concentration. The participants were able to focus on relevant environmental cues to maintain focus and concentration when before biofeedback training proved to be a great challenge. The participants agreed that the biofeedback training improved their ability to maintain focus over a long period of time. And the ability to concentrate on the breathing techniques learnt in the biofeedback training when necessary, which provided the ability to stay in control through circumstances that otherwise created a negative reaction. The inability to focus and concentrate can also be linked to experiencing the effects of a sport related concussion (Vaschillo et al., 2002). This allows for rebuilding positive channels of communication between the body and brain, and over the course of biofeedback training these positive channels of communication become ingrained in the participants physiological processing (Pop-Jordanova & Demerdzieva, 2012).

The four main sub themes that were outlined to provide major setbacks for all participants became controlled manageably or not existent after the biofeedback training. Through eliminating the silence by conducting focus group it created a format for open communication and peer support (Patton, 2002). The feedback by all participants in the focus group provided a level of confidence that it was okay to discuss their tribulations of psychological difficulties from the concussion. It also provided visibility to the injury by exposing the athletes to how there body's physiology reacts and can be controlled in real time is a recovery method that the

participants hadn't experienced. This ability to see how the body can be controlled to provide clean and positive brain processing provides a solid foundation to manage and overcome the psychological setbacks induced by a concussion (Thompson & Thompson, 2003).

The qualitative results from the pre-focus groups indicated that individuals experiencing psychological setbacks do not have the tools appropriate to cope from psychological setbacks. The participants in the pre focus groups created three distinct themes pertaining to anxiety and the difficulties returning to their new everyday reality after a concussion. Social anxiety, emotional control, friends, family, focus and concentrate throughout the day causing a negative psychological reaction (Covassin, 2007). The qualitative data shows a big improvement with integrating back into social scenes with a sense of calm and confidence. To eliminate the silence and the amount of time spent alone during recovery is the key to a positive rehabilitation, as the possibility to develop social anxiety will decrease.

Biofeedback training was beneficial to the participants because it allowed the participants to see which of their physiology responses reacts as a trigger to negative thoughts related to an adverse stimulus (Wilson, 2006). Once the participants can recognize these physiological responses and learn to control them, the negative thought processes was eliminated and a positive confident thought process was trained. Over time the body's communication with the brain is much more positive. Understanding and learning to control physiology can be a positive indicator to developing positive tools for positive emotional control. Controlling emotions within sport and outside of sport both pose different but equally as challenging circumstances (Landers & Arent, 2006). Activities from normal family gatherings to driving in the car together became great challenges to endure after experiences a concussion. Having the ability to train

the body and mind to understand what family situations have negative effects on emotional control is some evidence of the biofeedback training having a positive effect.

Making the injury visible provides understanding and empathy towards the individual injured with the concussion. For example, when breaking an arm or leg the recovery protocol requires a cast to stabilize the bone to heel. The cast is visible and even becomes an object where friends and family write on the cast connecting with the patient through support. The injured participants experience positive reinforcement and encouragement from being injured. However, in the case of a concussion, there are no scars, scrapes, cuts, casts, sling or crutch. It is not immediately clear that a person has experienced an injury. There is an invisible nature of the injury during recovery and every person reacts differently with sometimes delayed psychological symptoms. Due to this, it provides a great deal of challenges for the participants during recovery from a psychological perspective (Rosenbaum, 2009). A multi disciplinary approach to psychological recovery can be a positive recovery training method to improve focus and concentration, which research has shown to be a major hurdle when recovering from a concussion.

Understanding the changes to the self from a physiological perspective that happen after receiving a concussion can be very challenging (Terrell, 2004).The loss of the self can be a potential tragedy of sustaining a concussion. Examining the changes in physiology is seldom looked at and or treated in the recovery from a concussion. The data in the focus groups suggest, the loss of the self can be so profound, that if not treated, individuals may never fully recover fully from a concussion. Moser & Schatz (2012), state that a concussion can strip away learning, personal identity, and personal power.

The participants gained a deep understanding of how a change in muscle tension, skin conductivity and heart rate can affect self-confidence, self-control and positively reduced the need to self-medicate. When physiology is learned to be controlled and maintained in a set threshold the positive change with self-understanding and self-control provided great tools when psychologically recovering from a concussion.

Regaining self-control is a positive step from recovering psychologically from a concussion (Bloom, 2008). The loss of the self can be profound and developing an understanding of the physiological changes provided a great benefit to the participants for managing self-control in many situations that provided a negative change with the self. A negative step that the participants mentioned when controlling the self was the use of prescription drugs or self-medicating. Not resorting to self-medicating or relying on prescription medication. A big concern the participants expressed was being prescribed up to four prescription drugs or resorting to self-medicating to mask the psychological symptoms.

This can potentially indicate the usefulness and importance of learning to self-regulate physiology and essentially reprogramming the communication pathways from the body to the brain to communicate with each other that will create positive behavioural outcomes (Thompson & Thompson, 2003). This is the holistic benefit of biofeedback training. It provides a foundation for the participants to gain control without the assistance of prescription drugs or self-medicated outlets.

Catastrophe Model

The link between the Catastrophe Model and psychological recovery from a concussion may be one way to interpret the results from this study. In the pre focus

group, participants state that they are not able to control arousal levels returning to sport in order to have their best performance. High arousal occurs when a person is very excited or very angry. Anxiety, stress and nervousness can also be associated with high arousal (Hardy &Frazer, 1987). Taking the Catastrophe Model and applying the Inverted U theory, which puts forward the hypothesis of how performance is analyzed, also demonstrates what can happen during high and low levels of arousal.

The participants in the research expressed concerns when they felt arousal to be too high or too low and the negative psychological outcomes that occurred due to their arousal levels. For this reason, biofeedback is a positive tool because it allows the individual to control arousal levels until they learn how much arousal will provide positive performance outcomes. It is said that it is very difficult to achieve optimal arousal every time (Hanin, 1997). For this reason during a biofeedback training session, the researcher can set a range or threshold where the participant has the ability to control arousal.

Because every concussion reacts differently for every person, biofeedback allows for the personalization of training to meet individual needs. This flexibility is key when looking at each concussion as a standalone case. When looking at the Catastrophe Theory, the theory indicates that a severe drop in performance happens when emotions are not controlled (Hardy, 1996). Unlike the Inverted U Theory where there is a gradual decline in performance (Krane, 1992), the Catastrophe Model has an immediate performance decline when the participants goes past there optimal arousal (Hardy, 1990). With concussed participants, this theory fits the personal experiences shared in the focus groups. The immediate drop off can have the participants experiencing negative emotional control, stress and anxiety. Essentially, biofeedback is allowing the participants to train their individualized optimal arousal zone to achieve

psychological control.

Biofeedback

The research has brought forward benefits of a biofeedback intervention when recovering from psychological setbacks from sustaining a concussion. The biofeedback training uses electronic sensors, or electrodes that adhere to different areas of the body to detect changes in physical responses (Blumenstein & Tenenbaum, 2002). While the individual receives positive or negative feedback by listening or viewing feedback, the participant begins to recognize thoughts, feelings, and visualize mental images that contribute to physical reactions.

Furthermore, by learning, adapting and monitoring this mind and body connection to communicate, the participant may use the trained positive thoughts, feelings and mental images as indicators or reminders to become relaxed, or to control heartbeat, body temperature, muscle tension, skin conductance and brain wave patterns (Edmonds et al., 2009). Developing and learning to control these modalities demands practice over time. The participants mainly learn to develop these tools through trial and error. The participant trying to control their muscle tension or heart rate received a green light whenever these modalities dropped to the required threshold.

The positive impact created between the body and mind is that the participant remembers their thoughts and feelings at the moment and focus to maintain them to keep these modalities low. Over the course of the training, the participant educates themselves to control the targeted physiological response, and over time, is able to recognize when one or many of these modalities is elevated and what is required to reduce the modalities to mitigate the problematic psychological symptoms. The created adverse stimulus acting as a stress test was a two-minute video of concussion causing

hits with heavy metal music playing. This was to simulate the environment, which was causing psychological setbacks.

The four modalities that were the focus of the study all provided valuable information to the participants about how to control their psychological setbacks. Electromyography (EMG) was used to measure muscle tension in the shoulder which can be directly associated with headaches or feeling anxious. By receiving visual or audio feedback it allows the participant to train their body to adjust muscle tension allowing for a feeling of calm and relaxation.

Galvanic skin response (skin conductance) was used to measure perspiration or anxiety, which can be indicators of fear and anxiety. Skin conductance may be used in the treatment of anxiety, fears and stress, by learning how to control the amount of sweat or when the participant is experiencing these skin conductance responses. The tools are now existent to manage the negative reaction to anxiety and fear.

Regulating temperature plays a critical role in managing arousal. The regulation of temperature is also a way to treat headaches and anxiety disorders. By learning how to control the temperature on the surface of the skin it has immediate implications on attentiveness and finding the optimal arousal level. The last modality is heart rate through the management of breathing at six breaths per minute. Practicing correct breathing helps avert problematic breathing practices when facing a negative situation. Breath control training was used to treat panic attacks and a variety of stress-related conditions. BY combining the training to incorporate all four modalities this gave the participants the greatest chance to recover from psychological setbacks (Thompson & Thompson, 2006).

Focus groups

The mixed method approach was essential to eliminating the silence and invisibility of the concussion recovery. The use of focus groups to enable more richness in the research provided a platform for the participants to express how much the biofeedback intervention was a useful tool from the pre focus groups to the post focus groups (Creswell, 2013). To obtain accurate accounts of the improvements in daily life and sport from receiving the biofeedback intervention, the focus group were key in supporting the research objective. The types of focus group conducted were called triads (3 participants) in which three participants were present (Wasserman &Faust, 1994).

The strength of the focus group was participant interactions. This personal interaction allowed for them to discuss their psychological struggles from a concussion through personal disclosures. The groups also created a supportive environment for the participants to share dark and uncomfortable experiences. This allowed them to break the silence and hurt they have kept and let build up inside over a long period of time. By being placed in an environment with peers facing the same challenges created a sense of acceptability that they were not the only ones facing these psychological setbacks. At the conclusion of the focus group, the participants expressed a feeling of relief and confidence they have not felt since receiving the concussion.

As learned from the participants, so much of the recovery is spent alone which can create fear and depressive symptoms. Allowing the individual to be surrounded by peers provided a safe environment so that they had more confidence to talk about their struggles. Essentially, this method of capturing real life data in a social environment uncovered results that were not apparent in the quantitative data.

Limitations

Age gap and gender. The limitations of the study included a larger gap in age demographic than originally intended. However, the age group of the participants highlighted the vast nature of this injury; concussion is not only pertinent to youth but is still an issue through adulthood. Further, the sample was comprised of mostly male athletes with one female. The decision to leave the female athlete in the sample was an important consideration. After analysis, the female athlete spoke of many of the same struggles. Future research might focus on one gender however many of the struggles may appear across gender lines.

Sample size. The sample size in the study is relatively small at six participants therefore caution should be taken in the interpretation of the results, particularly the quantitative results. Future research would be to increase the sample size to 20 – 30 participants. The larger sample will enable researchers to make result more generalizable.

Recruitment. For the purposes of the study, the same sport was used to keep the environment consistent and to keep data consistent. All participants were cleared to play from a medical doctor after sustaining a concussion and that was a main criteria for recruitment. Future studies may want to examine athletes from a variety of sports or also explore individuals who have received a concussion from outside of the sport realm.

Neurofeedback. Although physiological markers were used for this study, a limitation was that neurofeedback was not included. Having the ability to go into greater depth regarding the benefits of neurofeedback and learning to control brain wave activity on the surface of the brain could prove to be another tool for

psychological recovery from concussion. A comprehensive self-help handbook could be developed specially looking at psychological recovery from a concussion using information from biofeedback and neurofeedback studies. This handbook could give tools about how to end the silence and invisibility that creates profound psychological issues. This may allow the concussion recovery process to be more targeted and encouraging to the individual.

Conclusion

Many athletes and medical staff focus the majority of their efforts on improving physical fitness and technical ability post-concussion. However, the latest research shows that emotional state plays a massive role in influencing a positive recovery from a concussion. This research has attempted to demonstrate that the use of focus groups and biofeedback training to assist concussed athletes in sport to cope with psychological concerns may be very beneficial in returning to play and life. The 'living in silence' that not just professional athletes encounter, but that the majority of the population who have sustained a concussion lives with, must change.

More could to be done than telling someone to rest. After enduring the required rest post-concussion to let the physical symptoms lessen, the people caring for the patients should be made to understand that addressing only the physical condition of the person is not the end of the treatment. The psychological factors have to be treated. Focus groups and biofeedback training has shown that it can be a positive alternative to using anti-depressives, sleeping pills, pain pills, drugs and alcohol, and assist individuals to work through depression, stress, anxiety, loss of confidence, fear and anger issues. Creating opportunities for dialogue allows for peer communication and helps to increase confidence by sharing the struggles faced every day. Through this

intervention, I witnessed that these struggles were like an elephant that was lifted off the shoulders of the participants. They did not feel alone anymore. I personally noted that participants hugged each other and cried throughout the process. The support they provided for one another was tremendously powerful. In addition, biofeedback allowed these individuals to see how their physiology works and reacts, which is key given the invisible nature of the injury.

Through this technique, athletes learn to develop strategies to control bodily outputs including muscle tension, rate of respiration, sweat, temperature, and heart rate. By having control at the physiological level, it allows for positive messaging to the brain. The body and brain are in constant communication. Individuals deserve the opportunity to be the people they were before sustaining a concussion so they can lead a positive healthy life moving forward. The emotional effects of a concussion can be profound and this is evidenced through reading personal anecdotes in the media and recent research that has come forward.

Our thoughts and emotions have a profound effect on our ability to perform at our best. Science says that people are hard wired to respond emotionally first and then think second when under pressure, anxiety and stress. The ability to manage one's emotional state under intense pressure and demanding conditions is really what separates the troubled recovery from a positive recovery. Biofeeedback training teaches athletes powerful techniques to balance the autonomic nervous system and control emotional states when returning to sport after a concussion. This type of intervention has the potential to help individuals better cope with the psychological issues sustained from receiving concussions.

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Table 1

Quantitative Results Biofeedback Stress Test

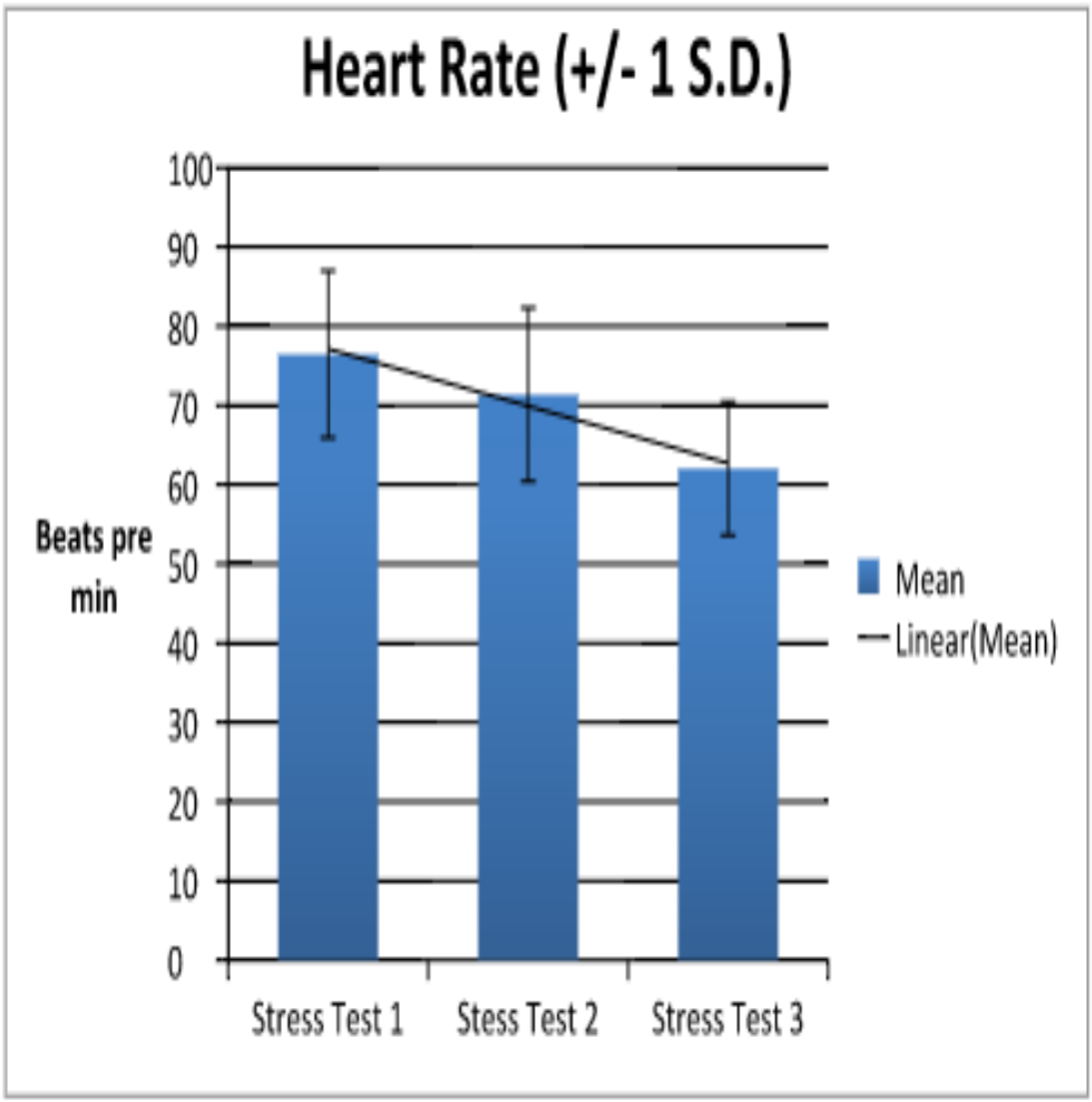
ANOVA Table

Modalities	df	F	Mean Square	p
Muscle Tension Left	(1,5)	0.002	0.152	0.967
Muscle Tension Right	(1,5)	0.071	5.177	0.801
Skin Conductance	(1,5)	0.596	0.466	0.475
Respiration Rate	(1,5)	1.571	22.688	0.265
Heart Rate	(1,5)	22.249	624.285	0.005*

Note. Results indicated that heart rate significantly decreased over the three time points (HR; F (1, 5) = 22.249, p = .005). A repeated measures ANOVA was also conducted on the additional three modalities test physiological control in order to determine if there was a significant decrease from stress test one to three.

Figure 1

Quantitative Biofeedback Stress Test : Heart Rate



Appendix A

Concussion Signs & Symptoms

Physical	Cognitive	Behavioral
Balance problems	Amnesia	Irritability
Vision problems	Confusion	Personality change
Dizziness	Easily distracted	Anxiety
Fatigue	Feeling in a fog	Depressed mood
Headache	Poor concentration	Easily frustrated
Lightheaded	Slow to answer questions	
Nausea/Vomiting	Disorientation	
Slurred Speech		
Ringing in ears		
Sensitivity to light		

Note. The table is adopted from the study "Can neurofeedback training enhance performance? An evaluation of the evidence with implications for future research" by Vernon, (2005).

Appendix B

Gradual Return to Play Protocol

Return to Play Stages
1. No activity
2. Light aerobic exercise
3. Sport-specific exercise
4. Non-contact drills
5. Full contact practice
6. Full return to play

*Note.*The table is adopted from the research, Retrieved, Zurich return to play guidelines (Zurich Conference, 2008)

Appendix C

Biofeedback Modalities

Name	Description	Abbreviation/terminology
Skin conductivity	A measurement of how much time an electrical signal takes to travel from one sensor to another through an individual's skin; it is a measurement of how much an individual sweats, because the more humidity is present on the skin the faster the electrical signal travels from sensor A to sensor B.*	Measurement of skin conductance has been referred to as: skin conductance level (SCL), galvanic skin response (GSR), psychogalvanic reflex (PGR), electrodermal response (EDR), and skin conductance response (SCR).*
Electrocardiography	Measures the heart's electrical activity and provides information about the interval, amplitude, and pace of the heartbeats.*	This assessment may provide different data to be used including heart rate (HR) and heart rate variability (HRV), which is the variation in the time interval between heartbeats. It has also been referred to as beats per minute (BPM), electrocardiography (ECG), and by its German nomenclature, Elektrokardiogramm (EKG).*
Electromyography	Is the measurement of muscle activity, or tension, taken by a sensor assessing the electrical signals emitted by the muscles when contracting.*	It has been referred to as: muscle electromyography (EMG), and surface electromyography (SEMG). Some EMG sensors made use of tiny needles; however, most of the current EMG sensors take measurements with the use o f a skin surface sensor*
Skin temperature	Is self-explanatory and refers to the temperature of an individual's skin. It is measured by a thermometer, or by an electric resistor placed on the surface of an individual's skin.*	It has been referred to as skin temperature (ST), or simply as temperature (T°).*

Electroencephalograpy	Is the measurement of brain activity through sensors placed on an individual's scalp.**	It has been given the following nomenclatures: Electroencephalography (EEG), neurobiofeedback, neurofeedback, and neurotherapy. **
Blood volume	It is a measurement of the amount of blood at a specific area of the body, at a given time. It is measured by a photoplethysmograph and provides information that can be calculated to estimate blood volume, heart rate and heart rate variability.*	Used nomenclatures include: blood volume pulse (BVP) and photoplethysmograph (PPG). Estimations of heart rate variability (HRV), and heart rate (HR) may also be traced by this sensor and measure (not as accurately as calculations gathered with the electrocardiograph)*
Note. * Adopted from the study "Determining the preferred modality for real-time biofeedback during balance training" by Bechly, Carender, Myles &Sienko, (2013). ** Adopted from the study "A Preliminary Study: Heart Rate Variability Biofeedback for Treatment of Postconcussion Syndrome" by Lagos, Thompson & Vaschillo, (2013).		

Appendix D

Pre Focus Group Questionnaire

Demographic Information

What is your age?

What sport do you play?

How long have you been playing?

Questions Related to Concussion and Recovery

When and how did you sustain your concussion?

When were you cleared to return?

What has been your biggest obstacle returning to sport?

How did you deal with missing game(s) or practice(s)? (Probe: Did you do any specific

behaviours while you were off?)

Explain frustrations you felt during your recovery from concussion? What aggravated you?

What are challenges returning to sport since receiving a concussion and why?

What are challenges returning to everyday activities since receiving a concussion and why?

What has bothered you most since sustaining a concussion?

Questions Related to Anxiety and Confidence

There are two types of anxiety. The types of anxiety are cognitive anxiety, which is the mental component (e.g., feelings of worry and apprehension) and somatic anxiety, which deals with physiological responses to stress (e.g., sweaty palms, butterflies feelings in chest area).

Have you experience anxiety after receiving a concussion?

Has your confidence dropped with regards to playing your sport?

How did you feel when you were unable to compete due to the concussion? (Probe: What

emotions did you feel?)

How did you manage the negative feelings?

What coping mechanisms did you use?

What triggered feelings of anxiety for you?

Do you have anything you would like to add?

Appendix E

Post focus group questionnaire

Demographic Information

Please state your name, age, and how long you have been back to activity since being cleared to play after your concussion.

What are your general impressions about the biofeedback intervention?

Questions Related to Concussion and Recovery

Has your biggest obstacle in returning to sport improved with the biofeedback intervention? Why or why not?

Have you seen an improvement with missing game(s) or practice(s) since going through the intervention? (Probe: What do you do when you are unable to attend a game or practice?)

Have frustrations you felt during your recovery from concussion decreased with the intervention? How? Give an example if you can.

Have the challenges returning to everyday activities since receiving a concussion improved and why?

How would you explain what you have learned through this training to someone who may not be familiar with biofeedback?

Describe ways in which you feel this training might be helpful in sport.(Probe: What specific strategies might you have used to keep yourself calm and focused in training?)

Describe ways in which you feel this training might be helpful in other areas of your life.

What process did you engage in to help yourself calm or refocus during training sessions?

What would you say to someone else who is considering biofeedback training after sustaining a concussion?

How will you continue to practice things you have learned in this training?

Any other thoughts or comments?

Appendix G

Pre-Focus Group Themes and Sub-themes

Theme	Sub-Theme	Category
Psychological challenges returning to sport	Fear of injury	
	Low self-confidence	
	Emotional control	
	Difficulties with focus and concentration	
Psychological challenges in personal life	Social Anxiety	Family
		Teammates
Challenges with self	Low self-esteem	
	Diminished self-control	

Appendix H

Post Focus Group Themes and Sub-themes

Theme	Sub-Theme	Category
Positive psychological changes returning to sport	Overcome fear	
	Regain Confidence	
	Enhanced emotional control	
	Improved Focus and Concentration	
Positive changes in the focus groups personal lives	Overcoming Social Anxiety	
	Positive Emotional Control	Family
		Friends
Positive changes with the self	Regained Self-control	
	Increased Self Esteem	

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Appendix I

Informed Consent

Research Project Title: Examining the use of a Biofeedback Intervention with Youth Sport Athletes Post Concussion and its Relationship to Anxiety and Confidence

Researchers: Stephen Dubienski, Primary Researcher, Faculty of Kinesiology and Recreation Management; Supervising Advisor: Dr. Leisha Strachan

Mr. Stephen Dubienski	Dr.LeishaStrachan
dubienss@myumanitoba.ca	leisha.strachan@umanitoba.ca
(204) 891-7413	(204) 474-8378

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your child's participation will involve. If you would like more detail about something mentioned here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information. If you would like to receive a summary of the findings, please indicate this desire in the space provided at the end of this form.

Your child has been asked to participate in this study due to their experiences of

receiving a concussion in sport and has been cleared to return to play. The purpose of this proposed research project is to use a biofeedback intervention to assist youth athletes overcome psychological setbacks due to receiving a concussion. Biofeedback training helps to control a body's physiological responses by monitoring breath rate, muscle tension, brain waves, temperature, heart rate, and sweat. This research is guided by the following question:Can biofeedback be a positive intervention for youth athletes overcoming psychological setbacks from sustaining a concussion?

I am requesting your child's voluntary participation in this study, which has the potential to lend valuable information to the sport governing bodies. The study will consist of two groups, a control group and a experimental group. The group that your child will participant in will be chosen at random. Your child'sparticipation in this study will be involved with a focus group, video diaries and biofeedback sessions and will involve:

- Focus group with the primary researcher (approximately 1-hour)
- Video diary where the participant is alone answering two to three questions (approximately 15 minutes)
- Member checking (approximately 2 hours): The transcripts of the focus group and video diary will be sent to you for review before the data analysis begins. This process will enable you to change or clarify your responses to the focus group questions.
- You will need to attend 13 training sessions lasting 15-20 minutes each (1 sessions per week for 12 weeks) where you will answer some questions about anxiety, confidence and psychological concerns related to your concussion, do some biofeedback training using the computer, and then answer some questions about the training during the

video dairy. At the last biofeedback session you will be asked some questions about what you thought about the training. Note, the control group will not be going through the biofeedback intervention training. However, if he or she wished to participate in a biofeedback intervention they will have the ability to do so.

The researcher will have access to all data (i.e. physiological baseline measurements). The information provided by the participants will not be discussed or disclosed to any other individual. The data provided in the research will be used in potential publication in academic journals and both public and academic presentations. The identities of the participants will be protected in all publications and presentations of the data obtained through this research project. The data obtained during the course of the study will be stored in a secure location (e.g. locked file cabinet in room 119 Frank Kennedy Centre at the University of Manitoba) that will only be accessible to the primary researcher and the supervising advisor. The identities of those who participated in the study will be protected in any presentation or publication. All data pertaining to the study will be shredded after a five-year period (January 2020) and video files will be deleted immediately after the transcriptions are completed.

The risk involved in the study is the potential identification as a participant based on the answers to the interview questions. To protect identity pseudonyms will be assigned to the participants. Participants may refuse to answer any questions. Participants may withdraw from the study at any time by contacting the primary researcher (Stephen Dubienski). Any data relating to individuals who have withdrawn from the study will be immediately destroyed. This includes shredding the informed consent, deleting video files, and shredding/deleting transcripts. There are no known physical, psychological, economic, or social risks associated with participation in this study.

This study is being completed as thesis research in accordance with the University of Manitoba. Dr. Leisha Strachan is the supervising advisor for this research and can be contacted at leisha.strachan@umanitoba.ca.

Your signature on this form indicates that you have understood to your satisfaction the information regarding your child's participation in the research project and agree to your child participate as participants. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. Your childis free to withdraw from the study at any time, and/or refrain from answering any questions you prefer to omit, without prejudice or consequences. Your child's continued participation should be as informed as your initial consent, so you and your child should feel free to ask for clarification or new information throughout your participation.

The University of Manitoba may look at your child research records to see that the research is being done in a safe and proper way.

The Education/Nursing Research Ethics Board (ENREB) at the University of Manitoba, guaranteeing quality assurance, has approved this study. If you have any concerns or complaints about this project you may contact any of the above-named persons or the Human Ethics Coordinator (HEC): Maggie Bowman at margaret.bowman@umanitoba.ca or 204-474-7122. A copy of this consent form has been given to you to keep for your records and reference.

Child's Name: _____ Date: _____

Parent/Guardian Signature: _____Date: _____

Primary Researcher's Signature: _____Date: _____

Primary Researcher:

Stephen Dubienski

Graduate Student, Faculty of Kinesiology and Recreation Management

University of Manitoba

Phone (204) 891-7314

dubienss@myumanitoba.ca

To be sent a summary of the results of this study please check here:

Yes:_____

No: _____

If yes, please include your email address or mailing address below:

Email address: _____

Mailing address: _____

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Appendix J

Assent Consent (Participants Ages 14 to 17)

Project Title: Examining the use of a Biofeedback Intervention with Youth Sport Athletes Post Concussion and its Relationship to Anxiety and Confidence

Researchers: Stephen Dubienski, Primary Researcher, Faculty of Kinesiology and Recreation Management; Supervising Advisor: Dr. Leisha Strachan

This letter will give you an idea about what I am researching and how you can help. If you have any questions, please ask me! Read this letter carefully...

The purpose research project is to use biofeedback to assist youth athletes experiencing psychological problems from sustaining sport related concussion. Using an experimental research design, the following question will be considered. Can biofeedback be a positive intervention for youth athletes overcoming psychological setbacks from sustaining a concussion?

You will be providing informative data that could assist to the recovery of a concussion. By participating in this study will be involved with a focus group, video diaries and biofeedback sessions. The important information that the study will receive through your participation will hopefully help you overcome your psychological setbacks from concussions and help other like yourself feel healthy. The goal is for you

to have increased confidence and decrease your anxiety when returning to your sport.

I want you to know that I will not be telling yourcoaches, parents, or any other teammates or kids what you say. Information provided will be monitored by researchers. Any harassing behaviour will not be tolerated and individuals will be removed from the study.

Only the researchers will be able to get into any of the information you provide. A report will be put together and may be presented or published in a journal. No one will know who answered the questions. Once the study is over, data will be erased after five years.

Your parent or guardian has said it's OK for you to be in this study. Would you like to help? You won't get into any trouble if you say 'no'. If you start the study then decide you don't want to do it anymore, that's OK too! You can ask questions at any time, now or later.

If you would like to help, please sign your name on the line below:

Your Name Print: _____Date: _____

Your Signature: _____Date: _____

Primary Researcher's Signature: _____Date: _____

Primary Researcher:

Stephen Dubienski

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To be sent a summary of the results of this study please check here: Yes:_____

No: _____

If yes, please include your email address or mailing address below: Email address: _____

Mailing address: _____

The Education/Nursing Research Ethics Board has approved this research. If you have any concerns or complaints about this project you may contact any of the above-named persons or the Human Ethics Secretariat at 474-7122, or e-mail margaret_bowman@umanitoba.ca. A copy of this consent form has been given to you to keep. The University of Manitoba Research Ethics Board(s) and a representative(s) of the University of Manitoba Research Quality Management/Assurance office may also require access to research records for safely and quality assurance purposes.