AN EXPLORATION OF THE PSYCHOLOGICAL RESPONSE AMONG NCAA STUDENT-ATHLETES RETURNING TO SPORT FOLLOWING A SPORTS-RELATED CONCUSSION

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ABSTRACT

AN EXPLORATION OF THE PSYCHOLOGICAL RESPONSE AMONG NCAA STUDENT-ATHLETES RETURNING TO SPORT FOLLOWING A SPORTS-RELATED CONCUSSION

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The purpose of this retrospective, survey-based study was to explore the extent of the psychological response when returning to play in collegiate student-athletes who had sustained a sport-related concussion. The survey was the Anterior Cruciate Ligament-Return to Sport Inventory adapted for use in a sports-related concussion (SRC) demographic. Thirty-three participants completed the survey and demographic and concussion history questionnaires via an online link upon return to full participation after sustaining an SRC. Qualtrics® was used to distribute the survey and SPSS software (22.0) was used for statistical analyses. The average scores for the confidence, emotional, and risk components were 7.19 $\pm$ 2.29, 5.78 $\pm$ 1.49, and 3.38 $\pm$ 2.44 respectively. Scores over 5.00 were considered to demonstrate a higher psychological response to that component. The 33 participants demonstrated a higher psychological response in both level of confidence and emotional reaction. They showed a lesser psychological reaction to risk. These athletes showed a higher emotional response upon returning to play, but also felt confident in their abilities and lacked concern for risk of re-injury. These preliminary data suggest that athletes feel greater and more variable emotions and have a high confidence level when returning to play. If further research continues to show a similar phenomenon, the information could be used to help athletes through the emotional stress of recovery while building their confidence to return to play.

ACKNOWLEDGMENTS

Writing this thesis has been an enlightening experience in more ways than one. This journey began back in September of 2014 when I was faced with the prospect of choosing a topic. It quickly escalated to the longest project I have ever undertaken in both time frame and word count and confirmed my belief in the importance of deadlines and commitment to a cause. This writing process reminded me of the necessity of being exact with words.

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CHAPTER 1

INTRODUCTION

1.1. OVERVIEW OF THE PROBLEM

Concussions have gained popularity in the media in the last several years, but their complex implications have not yet been fully understood and addressed in society to help better protect both active and inactive individuals alike. In the United States alone, 1.6 to 3.8 million concussions occur annually during sport-related activities (Langlois, Rutland-Brown, & Wald, 2006). This increasing number may be attributed to health care professionals becoming more aware of the problem and quicker to diagnosis a concussion for the safety of the athlete (Giza & Kutcher, 2014). Concussions are considered to be mild traumatic brain injuries with subsequent complicated pathophysiologic effects, including a metabolic cascade, prompted by linear or rotational forces on the brain (Giva & Hovda, 2001; McCrory, 2013; Meaney & Smith, 2011). Diagnosing a concussion involves a multi-faceted approach involving symptom scores, postural-stability testing, neurocognitive testing, and sometimes neuroimaging to rule out more serious pathology (Broglio et al., 2014; McCrory et al., 2013; Muir et al., 2014; Weinberger & Briskin, 2013). Rest and a specific progression back into activity when symptoms subside is the accepted rehabilitation (Broglio et al., 2014; Weinberg & Briskin, 2013).

The cumulative and long-lasting effects of concussions are still being researched as more information is gathered on conditions like postconcussion syndrome, second impact syndrome, and chronic traumatic encephalopathy. However, studies have shown that cognitive functioning and quality of life can be affected in the risk of subsequent concussions and the long-term effects of multiple concussions (Albright et al., 1985; Collins et al., 2002; Covassin, Stearne, & Elbin, 2008; Guskiewicz, 2003, 2005; Zemper, 2003). Albright et al. (1985) followed 342 collegiate football players over the course of 8 years with 87% of them sustaining a concussion. Twenty-six percent of them sustained a subsequent concussion during their career and on average took twice as long to recover (Albright et al., 1985). Guskiewicz et al. (2003) studied 2,905 collegiate football players and found that the risk of sustaining a successive concussion was 3.4 times greater in players who had already incurred three concussions compared to those who had not yet experienced a concussion. Finally, Zemper (2003) found the relative risk of concussion for the same demographic (i.e.,, collegiate football athletes) to be 5.8 times greater compared to their healthy counterparts. They also determined that one in 15 athletes who sustained a concussion may experience another concussion in the same season (Guskiewicz et al., 2003).

Collins et al. (2002) compared athletes with no history of concussion to those who had incurred three or more to determine if a difference in initial symptom presentation existed. The results indicated that the concussion group was 9.3 times more likely to present with loss of consciousness, retrograde amnesia, anterograde amnesia, and/or confusion (Collins et al.). Twenty-six percent of previously concussed athletes lost consciousness on the field after their subsequent concussion and 31.6% had prolonged symptoms (Collins et al.). Covassin, Stearne, and Elbin (2008) studied collegiate athletes and found that those with a history of two or more concussions experienced a longer recovery for verbal memory and reaction time on the ImPACT test than those with no previous history. Guskiewicz gave a general health questionnaire to 2,552 retired professional football players in 2005 and found that 61% of retirees experienced at least one concussion during their career and 24% endured three or more concussions. The results showed a correlation between concussion history and diagnosed mild cognitive impairment and self-reported memory deficits (Guskiewicz, 2005).

Studies analyzing the psychological response to musculoskeletal injury have been conducted and have led researchers to discovering a general trend of emotions post-injury that usually start with anger and depression and transition to coping and relief (Fallon & Quinn, 1999; Leddy, Lambert, & Ogles, 1994; Tracey, 2003). In a series of post-injury interviews with athletes experiencing moderate to severe injuries, Tracey (2003) found anger, depression, confusion, frustration with increased attention, helplessness, and worry to be the initial cascade. Those emotions were replaced with frustration with the loss of independence and a focus on the physical features of the injury (Tracey, 2003). A week into the rehabilitation process, athletes reported beginning to put more time into their academic work and reported that the decision of whether or not to go to practice was a daily torture (Tracey, 2003). Three weeks post-injury an upward swing in emotions took place as athletes began progressing toward a return to participation and found support in their friends and family (Tracey, 2003).

The fear of returning to play has already been shown to exist in those with visible injuries such as a reconstructed anterior cruciate ligament (ACL) and chronic back pain (Crombez, Vlaeyen, Heuts, & Lysens, 1999; Kvist et al., 2005). Kvist et al. (2005) examined fear of re-injury due to movement in patients post-ACL reconstruction and found the greatest fear of re-injury to exist in the 47% of patients who reported not yet returning to their pre-injury level of activity. Crombez, Vlaeyen, Heuts, and Lysens (1999) examined the relationship among pain-related fear measures and self-reported disability and behavior performance in patients with chronic back pain. The researchers found high correlations between those who reported an elevated pain-related fear and those who reported disability (Crombez, Vlaeyen, Heuts, & Lysens, 1999). While there is a plethora of research examining fear of return to play following

ACL or chronic low back pain, no research to-date has examined fear of return to play in concussed collegiate athletes.

1.2. SIGNIFICANCE OF THE PROBLEM

The problem faced today is that little research exists that specifically focusing on the psychological responses following a concussion. Examining these psychological responses specifically in concussed athletes has been limited to a few studies. On one study, Mainwaring et al. (2010) compared the emotional response of athletes who had their ACL reconstructed and concussed athletes using the Profile of Mood States. Results revealed that those rehabilitating their ACL injury had higher depression levels for a longer period of time and more total mood disturbance than those with a concussion. Concussed athletes reported mood disturbance and depression, but it subsided more quickly along with the symptoms (Mainwaring et al., 2010). The authors concluded that different patterns of emotional response accompany different injuries (Mainwaring et al., 2010).

In a similar study, Hutchinson et al. (2009) compared minor musculoskeletal injuries, concussed athletes, and a healthy control group using the Profile of Mood States (POMS) and found tension, depression, anger, loss of vigor, fatigue, confusion, and total mood disturbance to be common trends. The concussion group demonstrated elevated fatigue and decreased vigor that subsided with symptoms and the musculoskeletal group had the highest anger levels that didn’t resolve for two weeks on average after injury (Hutchinson et al., 2009). Limitations of these studies, include the difficulty in finding time for an ACL patient to complete neuropsychological testing due to their extensive physical rehabilitation and the small sample sizes involved. While these studies examined the psychological response to ACL and concussion injuries, they did not investigate concussed athletes and fear of returning to participation.

In one of the only studies to examine fear of re-injury and sport participation in all injuries, Covassin et al. (2015) investigated 525 injuries sustained in collegiate athletes who were asked to rate their fear of returning to sport and re-injury on a Likert-type scale. They found that athletes who sustained injuries with a time-loss from participation of more than three weeks reported an increased fear of returning to sport as well as an increased fear of re-injury compared to athletes with injuries of lesser time-loss (Covassin et al., 2015). However, this study did not separate out concussed athletes and fear of return to injury and sport participation.

Previous research has examined the fear of re-injury in musculoskeletal injuries such as ACL injuries and chronic back pain (Covassin et al., 2015; Crombez, Vlaeyen, Heuts, & Lysens, 1999; Kvist et al., 2005; Webster et al., 2008), however, no research to date has examined athletes’ fear of re-injury from an SRC. As conditions such as chronic traumatic encephalopathy, postconcussion syndrome, and second impact syndrome gain popularity as life-altering impairments, athletes may begin to fear returning to sport due to the increased risk of subsequent injury (Guskiewicz, 2005). Moreover, the risk of decreased long-term cognitive function may make athletes fear returning to participation due to these long-term effects of daily living impairments. Dijkers (2004) found that concussion patients specifically struggled to return to daily life after injury and reported low scores on the Health-Related Quality of Life survey. As a result, more research is warranted on the invisible injury that is an SRC and the potential for a fear of returning to participation. Therefore, this study will further investigate the emotional response that accompanies the rehabilitation process after an SRC with specific emphasis on the fear of returning to sport participation.

1.3. PURPOSE OF THE STUDY

The purpose of this study was to explore the level of psychological responses when returning to play in collegiate student-athletes who sustained a sport-related concussion within the past three months.

1.4. RESEARCH QUESTION

What is the level of the psychological responses in confidence, emotion and risk in athletes with a sport-related concussion?

1.5. EXPLORATORY QUESTION

Are there sex differences in level of psychological response in confidence, emotion and risk in athletes with a sport-related concussion?

1.6. OPERATIONAL DEFINITION OF TERMS

College Athlete: a student-athlete between the ages of 18 and 24 competing in a sport sponsored by the National Collegiate Athletic Association (NCAA)

Fear of re-injury: how much fear of re-injury an athlete reports in returning to sport participation

History of concussion: any previous brain injury diagnosed as a concussion by a health care professional

Sports-related concussion (SRC): a brain injury from a known mechanism sustained during team activity resulting in any combination of the following symptoms: loss of consciousness less than five minutes, headache, dizziness, nausea, confusion, amnesia, imbalance, attention issues, behavioral changes, depression, irritability, cognitive impairments, decreased reaction time, and/or balance deficits. (McCrory et al., 2013)

Athletic exposure: 1 athlete participating in 1 team practice or game (Hootman, Dick, & Agel, 2007)

CHAPTER 2

REVIEW OF LITERATURE

2.1. DEFINITION OF CONCUSSION

It is a common misconception that only a blow to the head or neck produces a concussion when, in reality, a blow to any part of the body that results in an impulsive biomechanical force being transmitted to the brain could cause a concussion (Weinberger & Briskin, 2013). Other former attempts at clarifying a concussive injury included loss of consciousness, amnesia, and Glasgow Coma Scale scores (Snedden, 2013).

Walker and Avant (2011) used a concept analysis method to attempt to produce a definition that would be clear enough to help health care professionals identify and treat concussions in a clinical setting. They found 200 articles using specific key words in varying databases with the inclusion criteria that the article was written in English and contained a distinct definition for a concussion, and no universal definition was found (Walker & Avant, 2011). In their search, they found that one of the first explanations for this type of head injury was thought up by Hippocrates in 400 BC, but the first definition similar to what was announced at the International Concussion in Sport Group Conference (McCrory et al. 2013) can be affiliated with the Arabic physician, Rhazes in the 900's who called the event "commotio cerebri," which he described as an irregular physiologic state without any lacerations to the brain (Walker & Avant, 2011). Lanfrancus amended that description in the 13th century by clarifying that this particular head injury was unlike other typical head injuries (Garrison, 1969). It was in the 16th century that the Italian physician daCarpi realized the injury concerned the brain matter colliding with the bony matter of the skull (Flamm, 1996). The term 'concussion' was not used until the 17th century when the mathematician Marchetti coined the term (McCrory & Berkovic, 2001).

As technology, such as the microscope, advanced throughout the Age of Enlightenment, the designation for traumatic blows to the head began to involve physiologic alterations and how such alterations present as clinical symptoms (McCrory & Berkovic, 2001). The sharing of information via literature eventually allowed explanations to include bits and pieces of position statements, dictionary blurbs, medical journals, and clinical protocols (Snedden, 2013). The definition eventually came to include the accepted mechanism, subsequent pathophysiological changes, and clinical presentation (Snedden, 2013). The slang terms previously used to describe the mechanism such as ‘getting your bell rung’ and being ‘jarred’ were eventually weeded out as they were often used to undermine the severity of the injury (Snedden, 2013).

The most recent and widely-accepted concussion description was produced at the 1st International Conference on Concussion in Sport held in Vienna in 2001 and is part of a position statement that says, “Concussion is a brain injury and is defined as a complex pathophysiological process affecting the brain, induced by biomechanical forces” (McCrory, 2013). This description then provides subsequent addendums to clarify certain aspects (McCrory, 2013). Concussions are not always a result of a traumatic blow to the head or neck but can also stem from an impulsive force being transmitted through the body (McCrory, 2013). Resulting symptoms are typically quick to arise and subside quickly as well and are most commonly due to a functional disturbance rather than structural (McCrory, 2013). These symptoms tend to be graded and disappear progressively (McCrory, 2013). This definition and related position statements provide a standard for concussion management for healthcare professionals. The National Athletic Trainers’ Association (NATA) published a position statement in 2014 that provides the guidelines specifically for athletic trainers treating concussions and encourages them to use this information to educate the general population on concussion management (Broglio, 2014). The document emphasizes awareness of the myriad of symptoms that can result from concussive blows and discusses the importance of a full evaluation after a suspected concussion including mechanism, level of consciousness, resulting signs and symptoms, neuropsychological function, and postural-stability findings to make an appropriate clinical decision (Broglio, 2014).

2.2. EPIDEMIOLOGY OF CONCUSSION

Approximately 1.6 to 3.8 million SRCs occur annually in the United States (Langlois et al., 2006). A prospective epidemiology study of 12 high schools male and female sports between 1997 and 2008 reported 2,651 concussions occurred during 10,926,892 athlete exposures (AE); thus, producing an incidence rate of 0.24 per 1,000 AEs (Lincoln et al., 2011). This incident rate is similar to the rate of 0.25 per 1,000 AEs found by Marar and colleagues (2012). Males made up 53% of all exposures and 75% of known concussions, and football specifically had an incidence rate of 0.60 and accounted for over half of all concussions while soccer had the highest incidence rate of concussion for female sports at 0.35 (Lincoln et al. 2011). In the sports played by both sexes, the risk of concussion for girls was about doubled (Gessel, 2007; Lincoln et al. 2011). The researchers found that the rate of SRCs in children and adolescents seeking medical care increased from 3.4-5.2 over the timespan, which is likely due to the heightened awareness of symptoms and long-term effects by the public (Lincoln et al. 2011). The actual number of concussions is likely higher than this statistic because it frequently goes unreported and undiagnosed (Lincoln et al. 2011).

An epidemiology study by Gessel et al. (2007) studied both high school and collegiate athletes in the United States compiling 1,730,764 exposures using injury surveillance systems.

They found that concussions made up of 8.9% and 5.8% of athletic injuries in the high school and college settings, respectively, and football and soccer represent the sports with the highest concussion rates in both age groups (Gessel et al. 2007; Hootman, Dick, & Agel, 2007; Marar, McIlvain, Fields, & Comstock, 2012). Collegiate athletes had a higher rate of concussion, but the proportion of concussions to other athletic injuries was highest in high school athletes (Gessel, 2007). In high schools, 137 concussions were sustained in practice compared to 259 that were endured during competition and another study found the rate during competition to be 6.4 and the rate at practice to be only 1.1 (Gessel et al. 2007; Marar, McIlvain, Fields, & Comstock, 2012). In football, running plays were found to result in the highest proportion of concussions due to player-to-player contact, and tackling specifically accounted for 67.6% of football-related concussions (Gessel et al. 2007). The rate of concussive injury was significantly higher in college athletics compared to high school in all sports except baseball; alternatively, concussions make up a greater proportion of all injuries in high school sports than in college (Gessel et al. 2007).

Another epidemiology study used the NCAA Injury Surveillance system to collect data from 15 collegiate sports across all divisions over the course of 16 years to determine injury trends (Hootman, Dick, & Agel, 2007). A total of 5,244,088 competition and 27,402,881 practice AEs were recorded that resulted in 72,316 and 109,160 injuries, respectively (Hootman, Dick, & Agel, 2007). The data showed that 9.8% of game injuries and 12.8% of practice injuries occurred to the head or neck, and concussions sustained totaled 9,150, which resulted in 5% of total injuries and a concussion rate of 0.28 (Hootman, Dick, & Agel, 2007). Fall football incurred the highest frequency with 4,404 concussions, which was 6% of all football-related injuries, and came out to a rate of 0.37 (Hootman, Dick, & Agel, 2007). Spring football resulted in the second highest number of concussions with 612, which was closely followed by women's soccer at 593 and men's soccer at 500 (Hootman, Dick, & Agel, 2007). Women's soccer had a higher rate of concussion than fall football with 0.41, but was still lower than spring football that had a rate of 0.54 (Hootman, Dick, & Agel, 2007). The least number of concussions are sustained in women's gymnastics with 64, but baseball had the lowest rate of concussion at 0.07 closely followed by women's volleyball at 0.09 (Hootman, Dick, & Agel, 2007).

2.2.1. *Age*

Age may play a role in concussion risk as well. A 2006 brief overview by Langlois, Rutland-Brown, and Wald found that children ages 0-4 and adolescents ages 15-19 are the most at risk for sustaining a concussion. Younger athletes have a higher rate of concussion compared to their older counterparts (Kerr, 2014). Proposed explanations include such individuals having decreased neck strength, and (for younger children) a head that is disproportional to neck strength due to the incomplete maturation process (Kerr, 2014). Queens et al. (2003) found that the smaller head mass of children causes an increased linear and rotational acceleration; thus, making them more susceptible to concussion. They also confirmed the results of previous research that found neck stiffness to play a role in lessening the acceleration of the head upon impact (Ekblom, 1994; Queen et al., 2003).

2.2.2. Gender

Women have twice the rate of concussion compared to males despite the fact that men sustain more concussions in sports played by both sexes (Daneshvar, Baugh, Nowinski, McKee, Stern, & Cantu, 2011; Gessel et al. 2007; Giza & Kutcher, 2014; Hootman et al., 2007; Lincoln et al. 2011). Daneshvar et al. (2011) found that women's basketball, soccer, and softball have higher concussion rates than their male counterparts and women's and men's lacrosse had similar rates. Such differences have been credited to differences in neck musculature strength, hormonal variations, and inconsistency of symptom reporting (Emerson, Headrick, & Vink, 1993; Giza & Kutcher, 2014; Tierney, Sitler, & Swanik, 2005). Like children, females may also have less cervical spine mass than men, which increases the acceleration of the head upon enduring a traumatic blow (Plagenhoef, Evans, & Abdelnour, 1983). This strength deficit has been attributed to the decreased girth exhibited in the sternocleidomastoid and upper trapezius muscles in women compared to men causing an upwards of 30-40% decreased isometric neck strength in females (Garces, Medina, Milutinovic, Garavote, & Guerado, 2002; Tierney, Sitler, & Swanik, 2005). Though knowledge in sex differences concerning concussions is growing, more research is needed.

2.3. MECHANISM OF CONCUSSION

The mechanism causing concussive trauma is either contact or inertial, both of which can occur when the head strikes or is struck by an object; whereas inertial loading can also exist when no contact is made as in the case of whiplash (Meaney & Smith, 2011). Concussions occurring by both mechanisms can involve linear or rotational forces (Rowson & Duma, 2013). Linear acceleration creates a transient intracranial pressure gradient and rotational acceleration is correlated with a strain response (Rowson & Duma, 2013). These forces affect the brain particularly because it sits freely in cerebrospinal fluid, which allows it to move at a different rate than the skull (Daneshvar et al., 2011). The differing rates make possible a collision between the brain and either the same side of the skull as the impact (coup) or the opposite side (contrecoup) (Daneshvar et al., 2011).

Using the cathode ray oscilloscope, Gurdjian and Lissner (1944) were able to study intracranial pressure fluctuations using the idea that compressing an electrolyte decreases its resistance. They found that at the time and location of impact, the oscillations associated with the compressive deformation of the skull last approximately 1/200 of a second and occur at a rate of about 700 cycles per second (Gurdjian & Lissner, 1944). In a study exploring intracranial pressure gradients, Thomas, Roberts, and Gurdjian (1966) found that intracranial pressure increased on the impacted side and decreased on the opposing side following concussive trauma. The deceleration involved with the impact could result in the stretching of the long axons at the base of the brain (Daneshvar et al., 2011).

Gurdjian and Lissner (1961) found elevated concentrations of shear strain in the craniospinal junction while studying a two-dimensional image of a skull filled with photoelastic liquid. Using bovine brains, Takhounts, Crandall, and Darvish (2003) found that brain matter is a nonlinear viscoelastic substance; thus, leaving it subject to the shear force associated with rotational acceleration. Edberg, Rieker, and Angrist (1963) had similar findings to Gurdjian and Lissner while studying a three-dimensional structure. These studies infer that varying pressure gradients caused by trauma lead to shear stresses in the craniospinal junction (Edberg, Rieker, & Angrist, 1963; Gurdjian & Lissner, 1961). Thomas et al. (1966) used their experiment to confirm the principles presented by previous researchers and concluded that every concussive impact varies considerably and depends on the rate and magnitude of the acceleration shift, pressure gradients, and the duration of said variables.

A study conducted by Broglio et al. (2009) studied an upwards of 20,000 high school football players and the forces they endured during football activities. They found that impacts to the top of the head resulted in the greatest force and shortest duration of impact and caused the most notable head jerk (Broglio et al., 2009). Forehead impacts were the most frequent and had the highest rotational acceleration (Broglio et al., 2009). Guskiewicz et al. (2007) conducted a study using accelerometer telemetry systems in the helmets of 88 collegiate football players where the accelerometers measured both the location and magnitude of acceleration of every individual impact. They found that during a session in which an athlete endured a concussive blow, the number of impacts ranged from 1-121 with an average of 27.7, and the magnitude of concussive impacts ranged from 60.51g-168.71g with an average of 102.8g. When they compared linear and rotational impacts, they found no notable difference in the magnitude of acute symptoms scores, postural stability, or neuropsychological functioning, which suggests that these factors are independent of the mechanism (Guskiewicz, 2007). Athletes in this study were 6.5 times more likely to endure an impact greater than 80g when hit at the top of the head compared to the sides, and almost half of the resulting concussions were initiated by hits to the top of the helmet (Guskiewicz, 2007).

An article by Meehan, d'Hemecourt, and Comstock (2010) was conducted to identify the associated mechanism, symptoms, and management of concussions in high school athletes during the 2008-2009 school year. They recorded 544 concussions and found that 76.2% of them were the result of athlete-to-athlete contact, specifically head-to-head in 52.7% of cases (Meehan, d’Hemecourt, & Comstock, 2010). Approximately 38.2% of instances were due to the injured player striking their head on an opponent somewhere other than their head (Meehan, d’Hemecourt, & Comstock, 2010). The remaining incidences were caused by contact with the ground in 15.5% and contact with an apparatus in 7.7% of cases Meehan, d’Hemecourt, & Comstock, 2010).

2.4. PATHOPHYSIOLOGY OF CONCUSSION

The pathophysiology of concussion has become better understood in recent years due to advances in neuroimaging techniques allowing researchers to noninvasively see the human brain when before they were relying on animal models (Giza & Hovda, 2001). The biomechanical forces alter cellular membranes creating transient membrane defects in the neuron; thus, resulting in the fluctuation of ions (Giza & Hovda, 2001). The release of potassium and the influx of calcium and sodium depolarizes the neurons, which prompts the release of glutamate (Giza & Hovda, 2001). As the ionic pumps work to restore homeostasis, intracellular energy stores are depleted, and a reduction in cerebral blood flow occurs (Giza & Hovda, 2001). This paradoxical uncoupling exacerbates the malfunctioning metabolism (Giza & Hovda, 2001). The time frame during which this metabolic disorder is occurring could be that which leaves the brain more vulnerable if a subsequent head blow were to be endured, according to experimental research (Giza & Hovda, 2001). The metabolite N-acetylaspartate has also been seen to take longer to normalize after a second concussion is endured (Giza & Hovda, 2001).

Diffusion tensor imaging has shown axonal stretching and swelling post-concussion, which decreases transport and connectivity in the brain as well as fractional anisotropy (Wilde et al. 2008). Fractional anisotropy is a scalar value that quantifies the directionality and magnitude of water diffusion on a scale from 0-1 and is affected by the make-up of white matter including axonal membrane status, myelin sheath thickness, number of intracellular neurofilaments and microtubules, and axonal packing density (Virji-Babul et al., 2013). The axonal damage has been identified as the culprit for long-lasting concussion symptoms, particularly vestibulo-ocular symptoms (Tjarks et al., 2013). The study by Virji-Babul et al. (2013) found higher whole-brain fractional anisotropy values in 10 concussed patients (ages 14-17) compared to their healthy controls, linking white matter structural integrity to concussion up to two months post-injury. The combination of axonal stretching and ion fluctuation brought on by the mechanical forces could lead to an increase in intracellular water and a decrease in extracellular water, which could then decrease radial diffusivity (Virji-Babul et al., 2013). These axons exist in compartments within neurons along with the tau protein, which increases after acute head trauma in combination with excessive cerebrospinal fluid (Neselius et al., 2013).

2.5. DIAGNOSIS OF CONCUSSION

Diagnosing a concussion is a complex, subjective clinical decision that must incorporate and consider a variety of physical, cognitive, psychological, and emotional disturbances (McCrory, 2013). Often times, clinical diagnosis is based largely on reported symptoms by the athlete and brief neurocognitive and balance tests completed on the sideline of the sporting event during which the concussion occurred (McCrory, 2013). These standardized tools help create a more objective and quantified picture that allows the clinician to follow the advancement of the athlete through the return-to-play protocol (Guskiewicz, 2004). For any of these tools to be helpful, a baseline score on symptoms, neurocognitive function, and balance for each athlete must be obtained prior to the occurrence of a concussion (Guskiewicz, 2004; Kaminski, Groff, & Glutting, 2009). In the absence of baseline scores, broad normative data from research studies can be used, but the resulting comparison lacks specificity for the concussed individual (Guskiewicz, 2004).

2.5.1. Symptom Score

Concussion symptoms are most commonly grouped into four categories: cognitive, emotional, sleep, and physical (Weinberger & Briskin, 2013). Typical clinical symptoms of concussion include headache, dizziness, nausea, confusion, amnesia, imbalance, attention issues, and behavioral changes (Aubry et al., 2002; McCrory et al., 2013). Symptoms resulting from cerebral dysfunction include cognition impairments, decreased reaction time, balance, and behavior (Aubry et al., 2002; McCrory et al., 2013). Psychiatric symptoms are often present as well and include depressed mood, anxiety, irritability, agitation, poor motivation, social withdrawal, and interpersonal difficulties (Konrad et al., 2011). The most often reported symptom is a bilateral headache made worse with bright light (known as photophobia) and loud noise with dizziness being the second most common (Weinberger & Briskin, 2013). Only 10% of athletes lose consciousness when sustaining a concussion, but doing so can warrant neuroimaging to rule out structural damage (Guskiewicz et al. 2003). Amnesia can be anterograde, which is memory loss starting at the time of injury, or retrograde, which is memory loss up to the injury (Collins et al. 2003). Prolonged loss of consciousness and amnesia, dizziness reported immediately after injury, and a high symptom score typically suggest a longer recovery time (Collins et al. 2003). Most typically, the onset of these symptoms is rapid and last only a short while before spontaneously resolving (McCrory, 2013).

Because of the variability in symptoms and their severity and duration, several symptom-scoring methods have been developed. Symptom checklists itemize the common symptoms associated with traumatic blows to the head and allow the athlete to specify whether or not he or she is experiencing each symptom with a yes or no answer (Guskiewicz, 2004). Graded symptom scales have displayed the most validity because they allow the athlete to indicate the severity of each of his or her symptoms on a Likert-type scale, and then each individual symptom score is added together for an amalgamated total (Guskiewicz, 2004; Weinberger & Briskin, 2013). The Post-Concussion Symptom Scale takes about five minutes to complete and consists of 22 symptoms patients rate on a scale of 0-6, none to severe, with total scores ranging from 0-132

(Lovell & Collins, 1998). The Maddock Questions have proven more sensitive than traditional questions for determining one's orientation and a potential concussion by asking questions specifically about the events of the current practice or competition as well as previous team activities (McCrea, Perrine, Niogi, & Härtl, 2012, 2013; Weinberger & Briskin, 2013).

2.5.2. Glasgow Coma Scale

The Glasgow Coma Scale (GCS) is a validated 15-point neurological scale that assesses eye opening, speech, and motor response to determine the level of consciousness with a higher score signifying a higher level of consciousness (Dziemianowicz, 2012). This scale is not without shortcomings and only uses a clinical score which allows a patient to suffer significant skull damage and still be considered to have endured a mild traumatic brain injury (Giza & Kutcher, 2014). The main purpose of the GCS is to eliminate a more significant brain injury from the differential diagnosis (Dziemianowicz et al., 2012).

2.5.3. Postural-Stability Testing

Postural-stability assessments should be incorporated into the diagnosing process as well to analyze the visual, vestibular, and somatosensory functioning that is often altered immediately as well as throughout recovery (Muir et al., 2014). The Sensory Organization Test (SOT) created by NeuroCom analyzes postural control by delicately adjusting a force plate and the surrounding walls to assess the components of balance: vestibular, somatosensory, and visual systems (Teel, Register-Mihalik, Troy Blackburn, & Guskiewicz, 2013). Six different conditions are tested to isolate the different balance components: fixed floor/fixed walls, fixed floor/closed eyes, fixed floor/sway wall, sway floor/fixed wall, sway wall/closed eyes, and sway floor/sway wall (Teel et al., 2013). The negative aspects of the SOT include its cost and immovable design (Asplund & Hunt, 2010).

The Romberg and Stork Test were used because of their simplicity in sideline use for testing postural stability, but they were found to lack sensitivity, specifically for the elite athlete population who tends to demonstrate improved coordination (Guskiewicz 2004; 2013). Then the Balance Error Scoring System (BESS) was created to provide a more challenging balance examination sensitive to the athleticism of the participants (Guskiewicz, 2004; 2013). The BESS test specifically assesses postural stability using three different testing stances: double leg, non-dominant leg, and tandem. All three stances are performed on both a flat, hard surface and an uneven surface, such as an Airex® pad (Guskiewicz, 2004; 2013). Each stance is performed for 20 seconds with the eyes closed and hands on the hips while errors are recorded by the tester (Guskiewicz, 2004; 2013). Errors include removing the hands from the hips, opening the eyes, stepping down, staggering out of the stance, not returning to the original stance within five seconds of stepping out of it, lifting the forefoot or heel off the testing surface, and flexing or abducting the hip more than 30 degrees (Guskiewicz, 2004; 2013). If 10 errors are recorded, the test is ceased (Guskiewicz, 2004; 2013).

A study with the purpose of finding the inter-rater and intra-rater reliability of the BESS used three scorers and 30 videotaped balancers and found the inter-rater reliability to be 0.57 and the intra-rater to be 0.74 and determined the overall test to be unreliable despite some reliable sub-categories (Finnoff, Peterson, Hollman, & Smith, 2009). A different study found that removing the double leg stances from the testing procedure improved the reliability of the overall test (Hunt, Ferrara, Bornstein, & Baumgartner, 2009). Almost 40% of concussed subjects report deteriorated balance in the week following the initial blow but typically recover by clinical standards within three to five days (Mucha et al., 2014). It has been suggested that balance impairments are isolated from vestibular-related pathology because athletes do not typically report balance and dizziness together (Mucha et al., 2014).

2.5.4. Vestibular/Ocular Motor Screening

A test specifically for identifying pathology of the vestibular system is called the Vestibular/Ocular Motor Screening (VOMS) and is warranted when dizziness, visual instability, or balance is reported as a symptom of concussion as it suggests impairment of the vestibular system (Mucha et al., 2014). The vestibular system recognizes alterations in head position and helps to maintain visual and balance control (Mucha et al., 2014). It consists of the vestibule-ocular system and the vestibulospinal system, which include little sensory organs of the inner ear (i.e.,, utricle, sacule, and semicircular canals) as well as connection to the brain stem, cerebellum, cerebral cortex, ocular system, and postural muscles, respectively (Mucha et al., 2014). These two systems complement each other but utilize different neuronal circuitry; so one system can be impaired while the other maintains normal function (Mucha et al., 2014).

The VOMS assesses vestibular and ocular motor impairments through self-reported patient symptoms after each testing to identify any aggravated symptoms resulting from the assessment (Mucha et al., 2014). It consists of five domains: smooth pursuit, horizontal and vertical saccades, convergence, horizontal vestibular ocular reflex, and visual motion sensitivity (Mucha et al., 2014). Pre and post-test symptoms are compared on a scale from 0-10 (none to severe) to determine if the VOMS test increased any symptoms (Mucha et al., 2014). The whole testing process lasts about five minutes (Mucha et al, 2014). A cross-sectional study analyzed 64 (ages 9-18) subjects suffering from a sport-related concussion compared to 78 healthy controls (Mucha et al., 2014). The researchers found the VOMS to have internal consistency and basic validity in comparison to the PCSS and have evidence to support the use of VOMS for identifying concussed subjects among a healthy population (Mucha et al., 2014). Concussed subjects had notably higher scores all components of the VOMS than their healthy counterparts (Mucha et al., 2014). Upper limits of ≥2 total symptoms after any of the VOMS tests or a near point of convergence distance ≥ five cm proved high rates of concussion identification, which suggests that VOMS can be an all-encompassing tool for identifying vestibular and ocular motor dysfunction in concussed subjects (Mucha et al., 2014). The researchers admitted that this was all preliminary evidence and more research should be done in this area to confirm significance (Mucha et al., 2014).

2.5.5. Standardized Assessment of Concussion

The Standardized Assessment of Concussion (SAC) is a sideline diagnostic tool used to quickly measure cognitive function by assessing orientation, memory (short-term and long-term), and concentration against a baseline score (McCrea, 2001). Its diagnostic validity has been deemed acceptable in people high school-aged and older, but lacks documentation of success in young children (McCrea 2001). A study conducted using high school football players found that the average baseline score was 25.6 out of 30 (McCrea 2001). A separate study analyzed both high school and college athletes and found that a decrease in score by one or more brought about a sensitivity of 94% and a specificity of 76% for a concussion diagnosis (McCrea 2001).

2.5.6. Sport Concussion Assessment Tool

The Sport Concussion Assessment Tool (SCAT) became a popular option after its original development at the 2nd International Conference on Concussion in Sport in Prague and includes the previously mentioned SAC, BESS, GCS, and Maddock Questions as well as a symptom check list (McCory et al. 2004, 2009, 2013). The 4th conference also produced the SCAT-3 and a child (ages 5-12) version of the SCAT-3 that includes a symptom reporting section for parents to complete as well as modified BESS and SAC sections (McCrory et al. 2013). What this test lacks is normative data to which scores can be compared. Shehata et al. (2009) conducted a study to determine baseline normative data for non-concussed and previously-concussed athletes using the SCAT-2. They studied college wrestlers, hockey players, and football players and found the mean post-concussion symptom scale to be 4.29 across all participants (Shehata et al., 2009). The median immediate recall score was five out of a possible five points, 91.6% of participants accurately said the months in reverse order, and an average score of six out of six was obtained for reciting digits in the reverse order (Shehata et al., 2009). The entire SCAT-3 only takes about 10 minutes to complete (McCrory et al. 2013).

2.5.7. King-Devick Test

The King-Devick (K-D) test measures processing speed, visual tracking, and saccadic eye movements by having subjects read single-digit numbers aloud from right to left and top to bottom as quickly and accurately as possible (Silverberg, 2014). The test consists of three different cards with the first card having straight lines connecting one number to the next, the second card having no lines, but significant spacing separating the rows, and the third card having no lines and minimal spacing between rows making tracking more difficult (Silverberg, 2014). Instantaneous self-corrections are not recorded as errors and the total time to complete the test is noted (Silverberg, 2014). The test has shown to be sensitive to acute symptoms of SRCs, but lacks validity in determining one's improvement during the recovery process (Silverberg, 2014; Tjarks, 2013). A study conducted by Tjarks et al. (2013) confirmed that improvements in K-D performance times correlate with improvements in Immediate Post-Concussion Assessment and Cognitive Testing (ImPACT) composite scores in 35 concussed subjects with symptoms lasting the duration of four clinical visits. The verbal memory component of the ImPACT was most closely associated with K-D scores (Tjarks et al., 2013). The convenience of sideline administration of this test makes it useful in initial identification of a concussion and aids in the decision to remove the athlete from play (Tjarks et al., 2013).

2.5.8. Computerized Neurocognitive Testing

Computerized neurocognitive tests are common tools used in identifying abnormal brain functioning and diagnosing a concussion. The success of utilizing such tests in making a sound return-to-play decision depend largely on having baseline data for the concussed athlete or normative data for each test being used as mentioned previously (Lovell, 2004; Shehata et al., 2009). The brain is responsible for various types of function, so cognitive tests must be all-encompassing including concentration, motor dexterity, information processing, visual memory, verbal memory, executive function, and brain stem function (Grindel, Lovell, & Collins, 2001). It is often necessary to test concussed patients more than once before allowing them to return to activity. However, multiple reassessments could produce a learning effect where the patient performs better on the second test, not because their cognitive function improved but because they remembered enough of the test to be able to increase their score (Grindel et al., 2001). Preventing the learning effect requires careful planning on the part of the medical professional so only minimal and necessary testing is completed (Grindel et al., 2009). Equivalent forms can also be used, which are different versions of the test that have proven to still be reliable (Grindel et al., 2009). The NATA position statement on concussion management recommends post-concussion neurocognitive testing to occur only once symptoms have subsided to prevent a practice-effect from developing (Broglio et al. 2014).

The ImPACT test is a popular tool for obtaining baseline scores and determining readiness to begin the return-to-play protocol. It is an online test that consists of a visual motor speed component, reaction time component, visual memory component, and verbal memory component that together provide information regarding visual processing, visual acuity, and oculomotor speed (Tjarks et al., 2013). The Windows-based test is user-friendly and takes approximately 20 to 25 minutes to finish and includes a demographic portion and graded symptom checklist (Erlanger et al., 2003; Lovell, 2004). The advantage of the ImPACT test is that the database has approximately 7,500 high school, college, and professional athletes from which to create the normative data, so if a baseline for an athlete is not available, the test can still be used effectively (Lovell, 2004). Due to the countless ways to arrange the stimuli, the ImPACT test has 5 versions that can be given to minimize practice effects (Lovell, 2004). It also has a built-in validity component to assess whether or not the test-taker is giving their full effort (Collins, Kontos, Reynolds, Murawski, & Fu, 2014).

The United States Department of Defense currently uses the Automated Neuropsychological Assessment Metric (ANAM) for baseline testing prior to deployment and to test service men and women who sustain concussive blows while on duty (Coldren, Russell, Parish, Dretsch, & Kelly, 2012). This automated test contains six subtests comprising of simple reaction time, procedural reaction time, code substitution, code substitution delayed, mathematical processing, and matching to sample, and the test taker’s composite speed and accuracy are analyzed (Coldren et al., 2012).

The Headminder Concussion Resolution Index (CRI) is another computerized neurocognitive exam that consists of six assessments testing memory, learning, and information processing that results in 5 index scores demonstrating processing speed, simple and complex reaction time, and simple and complex reaction time errors (Erlanger et al., 2003). The baseline test requires about 20 minutes to complete (Erlanger et al., 2003).

2.5.9. Neuroimaging

Neuroimaging is not typically warranted for concussed subjects because the results are typically negative, but computerized topography (CT) scans are sensitive to skull fractures and cerebral hemorrhage and should be done if symptoms include altered mental status, a GCS of 14 or less, and signs of a basilar fracture and more serious injury is suspected (Weinberg & Briskin, 2013). Single photon-emission (SPECT) testing and positron emission tomography can identify metabolic changes and blood flow occurring in a section of the brain, which could detect a concussion by identifying the associated metabolic changes (Asplund & Hunt, 2010). Magnetic resonance imaging (MRI) is appropriate to identify pre-existing pathologies causing long-lasting symptoms (Weinberg & Briskin, 2013). A functional MRI (fMRI) has been deemed useful because it analyzes neural function during a task (Hunt & Asplund, 2010). Magnetic Source Imaging (MSI) follows brain activity in real time by conduction via the brain, skull, and scalp (Hunt & Asplund, 2010). Diffusion Tensor Imaging (DTI) is especially sensitive to alterations in the microstructure of frontal white matter and is a means of quantifying the structural integrity of the brain's white matter, particularly any small reductions (Virji-Babul et al., 2013). Despite the fact that neuroimaging has not been shown to assist in diagnosing a concussion, such technology should be used when life-threatening trauma is expected (Hunt & Asplund, 2010).

2.6. RETURN-TO-PLAY FROM CONCUSSION

Once a concussion is identified, the typical and accepted treatment is both physical and cognitive rest (Weinberg & Briskin, 2013). Physical rest decreases the chances of worsening symptoms while also avoiding circumstances where a second concussion could be sustained, and cognitive rest has been found to help reconcile symptoms more quickly (Weinberg & Briskin, 2013). Cognitive rest could include time away from school and all of the associated work as well as less screen time with computers, phones, tablets, and television (Weinberg & Briskin, 2013).

Returning previously concussed athletes to play requires a multi-faceted approach that puts the health and well-being of the athletes at the forefront of all final decisions. Return-to-play protocols should be individualized and no athlete suspected of having a concussion should be allowed to return-to-play on the same day as the injury or before all symptoms have subsided (Broglio et al. 2014; Guskiewicz, 2004; McCrory, 2013; Weinberg & Briskin, 2013). The progression into activity should only begin once all symptoms have resolved for at least 24 hours and neurocognition has resumed normal functioning when compared to baseline testing (Broglio et al. 2014; Weinberg & Briskin, 2013). The involvement of a physician in the return-to-play process is encouraged (Broglio et al. 2014; Weinberg & Briskin, 2013). The progression itself is stepwise in nature and increased the duration and intensity of the activity each day unless symptoms return.

The recommended return-to-play stepwise process following a concussion includes: 1) No activity, complete rest until asymptomatic, 2) Light aerobic exercise such as walking or stationary cycling, no resistance training, 3) Sport specific exercise and progressive addition of resistance training, 4) Non-contact training drills, 5) Full contact training after medical clearance, and 6) Game play (Aubry et al., 2002; McCrory et al., 2005; McCrory et al. 2009, 2013). The Concussion in Sport group recommends that injured athletes should continue to proceed to the next level if they remain asymptomatic at the current stage. If concussion symptoms reappear, the athlete should revert back to the previous asymptomatic stage and resume the progression after 24 hours (Aubry et al., 2002). These guidelines allow for a more individualized approach when returning an athlete back to competition from concussion.

The University of Pittsburgh Medical Center has also pioneered some rehabilitation methods for concussed subjects that do not call for complete physical rest, but rather light physical activity during the acute stage of recovery if an athlete's ImPACT scores do not show significant impairment (Kissick & Johnston, 2005; Lovell, 2004). Kissick and Johnston (2005) published an article regarding the safe return of athletes to sport following concussion and used a comparison with a runner who would not be removed from all activity due to a tibial stress fracture because he would lose all conditioning; instead, he would initially be allowed to do activities that do not exacerbate the condition. The second stage of rehabilitation is returning normal functioning of the injured body part before lastly gaining back sport-specific skill (Kissick & Johnstron, 2005). They argued that concussions are minimally different and such athletes can be allowed to perform light activity that does not worsen the condition once symptoms have subsided (Kissick & Johnston, 2005).

2.7. CUMULATIVE EFFECTS OF CONCUSSION

The cumulative effects of concussion are getting notable attention in the media currently, but the literature is still trying to develop conclusions on topics like a potential increased risk of concussion once one has been sustained, longer recovery times with each subsequent concussion, and lasting neurocognitive effects that could affect one's daily life. If the literature proves such concerns to be legitimate, athletes may quickly begin to weigh the pros and cons before returning to play.

A study conducted at the University of Iowa analyzed the head and neck injuries sustained by 342 football players from 1975-1982 to determine the pattern of such injuries as well as the association to potential factors contributing to a subsequent risk of injury (Albright, McAuley, Martin, Crowley, & Foster, 1985). Each participant underwent a screening including previous history of concussion, radiographs of the neck, and general physical examination; any irregularities found during screening deemed the athlete abnormal (Albright et al., 1985). Throughout the duration of the study, 100 players sustained a total of 175 non-fatal head and neck injuries, and head pathologies alone resulted in 115 injuries of 78 players causing a total of 574 days of disability with 87% of those injuries considered concussions (Albright et al., 1985). The average recovery time for the concussed subjects was 5.38 days, and only 15 of them resulted in more than seven days lost from activity with two of those cases permanently removed from football (Albright et al., 1985). 78 of the participants experienced their initial head injury in college and, on average, recovered in 2.31 days; however, 26% endured a subsequent injury during their career and took an average of 4.89 days to return to activity (Albright et al., 1985). Albright et al. found that football players who were abnormal during their screening were twice as likely to sustain a head or neck injury compared to their normal teammates, and a higher degree of abnormality led to more severe successive injuries (1985). 29% of the participants endured a head or neck injury during their careers, and of those athletes, 42% sustained an additional injury to the first, and 24% of injured athletes had a recurrent injury during the same season (Albright et el., 1985).

Guskiewicz et al. (2003) studied 2,905 collegiate football players across all divisions with the intent of analyzing whether or not those with a history of concussive injuries had a higher rate of head injuries during their college careers. They found that the risk of sustaining another concussion was 3.4 times greater in players who had already sustained three concussions compared to those who did not have a previous history of concussion (Guskiewicz, 2003). Additionally, athletes with two previous concussions were 2.8 times more likely and athletes with only one previous concussion were 1.5 times more likely to sustain a subsequent concussive injury than athletes without a previous history of concussion. These researchers also concluded that one in 15 athletes who sustain a concussion may incur another concussion in the same season.

Collins et al. (2002) matched 60 high school athletes with no history of concussion with 28 athletes who had sustained three or more concussions to compare the on-field symptom presentation of loss of consciousness, retrograde amnesia, anterograde amnesia, and confusion. They found that athletes who had incurred three concussions were 9.3 times more likely to demonstrate at least three of the four symptoms compared to their counterparts with no previous history of concussive injury (Collins et al., 2002). Only 5% of subjects with no prior history of concussion lost consciousness on the field compared to 26% of the participants who had previously sustained a concussion (Collins et al., 2002). Of all participants with no history of concussions, 9.4% of them had an on-field mental status change lasting longer than 5 minutes while 31.6% of previously concussed athletes had prolonged symptoms (Collins et al., 2002).

Zemper studied high school and college football players during the 1997 and 1998 seasons to measure the relative risk of cerebral concussion among those with a previous history compared to those not previously concussed, and over the course of two seasons, 572 concussions were documented, 161 with a previous history and 411 without (Zemper, 2003). He calculated the relative risk of concussion for previously concussed athletes to be 5.8 times greater than for athletes who have never endured a mild traumatic brain injury (Zemper, 2003).

Another study compared football players who had sustained one concussion to an age-matched football player with similar education and football background who had sustained two concussions (Macciocchi, Barth, Littlefield, & Cantu, 2001). The researchers wanted to determine if a second injury resulted in more detrimental neurocognitive defects than a single concussive blow. They found that the players who had sustained two concussions did not show any worsened post-concussion neurocognitive impairments when compared to their controls, and athletes who had endured two concussions performed better on postseason assessments than they had on preseason testing (Macciocchi et al., 2001). The number of football players reporting post-concussion symptoms notably increased after one or two concussions, but all symptoms were found to diminish by 10 days post-injury (Macciocchi et al., 2001). Headaches were the most commonly reported symptom by all subjects; however, those who had sustained multiple concussions reported more symptoms compared to their controls, but the increase in symptom reporting was not statistically significant (Macciocchi et al., 2001).

Another study examined collegiate athletes to evaluate the correlation between concussion history and postconcussion neurocognitive performance (Covassin, Stearne, & Elbin, 2008). All subjects were baseline ImPACT tested and subjects sustaining a concussion during the study were tested again at one and five days postconcussion (Covassin, Stearne, & Elbin, 2008). The results showed that concussed college athletes with a history of two or more concussions took longer to recover on verbal memory and reaction time than those athletes with no previous history (Covassin, Stearne, & Elbin, 2008).

A study by Guskiewicz et al. (2005) gave a general health questionnaire to 2,552 retired professional players to determine if previous head injury increased the risk of incurring mild cognitive impairment later in life. The researchers found that 61% of the retirees suffered at least one concussion during their career and 24% suffered from three or more (Guskiewicz, 2005). When the results of the questionnaires were analyzed, the association between history of concussion and diagnosed mild cognitive impairment as well as self-reported memory deficits were found to be statistically significant and the association strengthened as the number of sustained concussions increased (Guskiewicz, 2005). The authors propose that recurrent concussions could lead to dementia-related symptoms in this particular demographic, but they could not factor in the effects of subconcussive blows due to the retrospective nature of the study (Guskiewicz, 2005).

Concussion symptoms can last several years post-injury and typically cannot be explained with neuroimaging as the images fail to show any brain damage potentially causing the lingering symptoms (Konrad et al., 2011). A study conducted by Konrad et al. (2011) analyzed 33 concussed patients (and their healthy controls) an average of six year post-concussion using MRI and found that cognitive impairments including learning, long-term memory, working memory, attention, and executive functions lingered well into one's life after a concussion. Despite the lack of physical evidence explaining the reported symptoms, these patients still require medical attention and are often denied and given the label 'malingerer' (Konrad et al., 2011).

Collins et al. (1999) conducted a study that sought to determine the association between a history of concussions and a diagnosis of a learning disorder in collegiate football players as well as its influence on baseline neuropsychological testing. Between May 1997 and February 1999, 393 collegiate football players were baseline tested with the battery used by the National Football League and the 16 athletes who incurred a concussion during the study were paired with a control from the sample and then underwent subsequent neuropsychological testing for comparison at 24 hours, three days, five days, and seven days postconcussion (Collins et al., 1999). The researchers found that a prior history of two or more concussions and a learning disorder are linked to decreased baseline cognitive performance within the population of collegiate football players and are associated with long-term executive functioning and information processing deficits and a proliferation of reported symptoms; these associations were not seen in those with a history of only one concussive episode (Collins et al., 1999). Athletes with a diagnosed learning disorder and a history of two or more concussions performed worse on neuropsychological testing compared to those with a concussive history but no learning disorder (Collins et al., 1999). However, a limitation to this study was its small sample size; therefore, caution should be taken when interpreting the results.

Division III college athletes were compared to a non-athletic population in a study conducted by Killam, Cautin, and Santucci in 2005 to determine the lingering neuropsychological effects of concussion during contact sports. Participants were divided into four groups consisting of non-athlete/non-concussed, athlete/non-concussed, athlete/non-recent concussed, and athlete/recent-concussed and were given the Repeated Battery for the Assessment of Neuropsychological Status (RBANS), Postconcussion Syndrome Checklist, and Stroop Task (Killam, Cautin, & Santucci, 2005). The results showed that athletes with a recent concussion scored lower than control subjects in the immediate and delayed memory areas, and the athletes in the recent concussion group scored more poorly compared to the athletes in the non-recent concussion group on the RBANS test (Killam, Cautin, & Santucci, 2005). Interestingly, the researchers found memory deficits in athletes who reported no history of concussion, which the researchers hypothesized could be due to the physicality demanded by the training that accompanies college athletics; similarly, non-athletes outscored the athletic population on the whole RBANS (Killam, Cautin, & Santucci, 2005).

A study to determine the lasting effects of concussion in young people was conducted in 35 healthy volunteers between the ages of 14-19. Out of these 35 participants, 21 had not sustained a concussion in the last six months and 14 had suffered a concussion within a week of testing (Moser & Schatz, 2002). The RBANS was used as the cognitive testing battery and was completed by all participants (Moser & Schatz, 2002). The results of the testing indicated that the recently concussed group scored significantly lower on the RBANS than the control group, and the group who had sustained two or more concussions outside the six-month window most closely resembled the recently concussed group. The researchers suggest that enduring effects after a concussion may exist in younger athletes (Moser & Schatz, 2002).

A follow-up study conducted by Moser, Schatz, and Jordan (2005) studied the prolonged neuropsychological effects in 223 high school athletes who were divided into four groups based on their concussion history: not previously concussed, symptom-free with one previous concussion, symptom-free with two or more previous concussions, and recently concussed within one week of testing (Moser, Schatz, & Jordan, 2005). The RBANS, a symptom checklist, an interview, a demographic form, and the Trail Making Tests were used to obtain information about the subjects and their current level of neuropsychological function (Moser, Schatz, & Jordan, 2005). The results showed the recently concussed individuals performed more poorly on the attention and concentration tests than the athletes with no previous history, and athletes who had experienced two or more concussions performed comparably to athletes who has just sustained a concussion in the last week and had similar grade point averages (Moser, Schatz, & Jordan, 2005).

This research suggests that a previous history of concussion could increase the chance of sustaining a subsequent concussion (Guskiewicz, 2003; Zemper, 2003) as well as enduring a prolonged recovery (Albright et al., 1985; Moser, Schatz, & Jordan, 2002; 2005), and possibly even an increase in symptoms (Collins et al., 2002).While these studies all support that a history of concussions can lead to lasting neurocognitive effects and a greater risk of sustaining another concussion, some researchers have reported contrary findings. For example, Bruce and Echemendia (2009) conducted a study with 1,512 male collegiate athletes not having sustained a concussion in the last six months who underwent neuropsychological testing, both traditional and computer-based. They found no association between a history of self-reported concussion and neuropsychological performance (Bruce & Echemendia, 2005).

Meanwhile, Guskiewicz et al. (2002) compared 240 collegiate male soccer players to non-soccer athletes and non-athletes to determine if long-term neuropsychological dysfunction exists. The subjects completed concussion history questionnaires and baseline neuropsychological testing. Results revealed that there were no neurocognitive deficits when compared to the controls, nor did their scholastic aptitude seem to be affected by heading in soccer (Guskiewicz et al., 2002).

Another study examined 867 male high school and university athletes who were separated into three groups based on their concussion history: no previous concussions, one previous concussion, or two previous concussions (Iverson, Brooks, Lovell, & Collins, 2006). All subjects completed the ImPACT test during their preseason training to acquire a baseline score (Iverson et al., 2006). The researchers found no significant difference in any of the six ImPACT subsets or in the symptom reporting of the previously concussed athletes compared to those who have no previous history (Iverson et al., 2006). Though debate still exists on whether or not prolonged effects of concussion are present in athletes, enough evidence has been found to warrant more research in the area to protect athletes from long-term neuropsychological harm.

2.7.1. Postconcussion Syndrome

Giza and Kutcher (2014) describe Postconcussion Syndrome (PCS) as “persistent symptoms…lasting a variable duration following a concussion.” The diagnosis for PCS is subjective, as with concussion in general, and is not made using any neurocognitive testing or threshold from previous concussions (Kozlowski, Graham, Leddy, Devinney-Boymel, & Willer, 2013). Gerber and Schraa (1995) listed symptoms as including irritability, depression, anxiety, memory loss, poor concentration, reduced processing speed, headache, dizziness, nausea, fatigue, sleep and visual disturbances, and sensitivity to light and sound. A different study attempted to compare symptoms of chronic pain with postconcussion symptoms via the Rivermead Post-Concussion Questionnaire (RPCQ) in 63 patients with chronic pain and no history of neurological issues and 32 patients with a mild traumatic brain injury not incurred from striking their head with a GCS score between 13 and 15 (Smith-Seemiller, Fow, Kant, & Franzen, 2003). Total scores on the RPCQ revealed no difference between the chronic pain sufferers and the concussion group, but when the scores were broken down into somatic, cognitive, and emotional sub-tests, concussion patients scored lower on the cognitive portion reporting difficulty with memory, thinking, and noise and light sensitivity while those with chronic pain scored lower on emotional symptom questions (Seemiller, Fow, Kant, & Franzen, 2003).

2.7.2. Second Impact Syndrome

Cantu and Voy (1995) described second impact syndrome (SIS) as an athlete who has already received a head injury sustains another head injury before the symptoms associated with the first have resolved. This event causes cerebral swelling, which quickly leads to death from brainstem herniation (Cantu & Voy, 1995, McCrory, Davis, & Makdissi, 2012). Despite the agreement in definition of SIS by these authors, they disagree on the evidence of existence. Cantu and Voy (1998) reviewed five case studies in their study where each athlete had a concussion with lingering symptoms before collapsing into a comatose state and largely increased cranial pressure was found during their autopsy. McCrory et al. (2012) says the evidence has shown to be only anecdotal with the accepted criteria failing to be met in most instances. McCrory and colleagues found that most case studies lack a confirmed first head blow, documentation of unresolved symptoms, verified second impact with associated cerebral deterioration, or cerebral swelling found during autopsy that has no other cause. This study revealed that of the 25 examined deaths, 9 were indeed caused by brain injury and 16 were mostly due to cardiovascular pathology, and the 9 brain injury deaths were caused by intracerebral hematoma or traumatic subarachnoid hemorrhage because of damage to the cerebral artery (McCrory, Davis, & Makdissi, 2012). Furthermore, McCrory et al. (2012) also found that no documented cases of SIS existed outside the United States.

2.7.3. Chronic Traumatic Encephalopathy

One form of neurodegeneration (originally seen in boxers) caused by repeated blows to the head is known as Chronic Traumatic Encephalopathy (CTE) and can cause cerebral atrophy, particularly in the frontal and medial temporal lobes, hypertrophy of the ventricles, cavum septi pellucidi with fenestrations, shrinking of the mammillary bodies, dense tau immunoreactive inclusions, and a TDP-43 proteinopathy (Gavett, Stern, & McKee, 2009; 2011; Stern, Riley, Daneshvar, Nowinski, Cantu, & McKee, 2011). The specific tau isoforms present in CTE are undifferentiated from tau isoforms present in Alzheimer’s Disease (AD) and typically present with the general lack of beta-amyloid deposits (Stern et al., 2011). A small percentage of people, the TDP-43 immunoreactive inclusions and neurites can be seen in the anterior horns of the spinal cord and motor cortex, along with corticospinal-tract degeneration, a decrease in anterior horn cells, and ventral root atrophy, which is similar to the pathophysiology of amyotrophic lateral sclerosis (ALS) and presents with significantly decreased strength, muscular atrophy, spasticity, and fasciculations (McKee, 2009; Stern et al., 2011). These distinct similarities suggest that ALS could potentially stem from an earlier concussion (Stern et al., 2011).

People presenting with CTE have symptoms distinct from long-term concussion symptoms or PCS because it is a neurodegenerative disease attacking the neurons with symptoms specific to the region of the brain progressively deteriorating in health and function (Stern et al., 2011). This makes the onset insidious in nature and symptoms are often overlooked or attributed to some other pathology (McKee, 2009; Stern et al., 2011). Sex, age, genetic predisposition (carriers of the APOE4 allele), and previous cognitive or psychological disorders could be risk factors exacerbating the progression of CTE, however, more research is needed to verify these risk factors (Stern et al., 2011). These mid-life changes can then cause gradual cognitive, memory, and motor impairments (Gavett et al., 2011). The display of cognitive symptoms is not unlike other neurodegenerative diseases, but the behavioral and mood impairments is currently fairly unique to CTE and greatly alter one's ability to function in daily activities (Stern et al., 2011).

Medical professionals have not yet found diagnostic criteria for CTE (Gavett et al., 2011). No confirmed case of CTE exists that has a history of only one traumatic head blow; rather, in most cases, the history includes repeated head blows, specifically endured before recovery from the initial blow has taken place (Gavett et al., 2011). The cause of CTE being repeated concussions in earlier years has not yet been confirmed due to the current evidence being in the form of case reports (McCrory et al., 2012). Prevention of CTE includes taking steps to minimize repeated head trauma exposure including limiting the number of full-contact practices, modifying rules to limit potentially dangerous situations, and developing protective equipment (Gavett et al., 2011).

2.8. PSYCHOLOGY OF INJURY RETURNING TO SPORT & DAILY ACTIVITY

2.8.1. Models of Response to Injury

The experience of sustaining an injury is an emotional one for any athlete (Fallon & Quinn, 1999), and models have been developed to help map out the emotional response involved in injury. The Kübler-Ross model was originally developed to explain the emotions of the surviving loved ones of the deceased, but it was then found to be relevant to many aspects of life including athletic injuries (Kübler-Ross, 1969). The five stages of Kubler-Ross include denial, anger, bargaining, depression, and acceptance (Kübler-Ross, 1969). Sports medicine professionals soon found that athletes' emotions upon being injured are more unique than the Kubler-Ross model demonstrates and began to develop cognitive appraisal models to analyze the grief that accompanies an athletic injury (Brewer, 1994; Fallon & Quinn, 1999). The theory behind these models is that each athlete will exhibit a different emotional response at different milestones throughout the recovery process (Fallon & Quinn, 1999).

An integrated model response to sports injuries was developed after the existing literature was reviewed (Morrey, Wiese-bjornstal, Shaffer, & Smith, 1998). This model illustrates that personal and situational factors influence the cognitive appraisal that begins immediately following injury (Morrey, Wiese-bjornstal, Shaffer, & Smith, 1998). As the recovery process begins to take place, emotional and behavioral responses affect both the physical and emotional recovery (Morrey, Wiese-bjornstal, Shaffer, & Smith, 1998). Immediately upon sustaining an injury, athletes begin to appraise the extent of the injury, the likelihood of recovery, and the social support available to them, and they develop their self-perception as an injured athlete (Morrey, Wiese-bjornstal, Shaffer, & Smith, 1998).

Andersen and Williams (1988) proposed a stress-injury model supporting that pre- and post-injury factors affect the psychological response during recovery and that response changes over time as the process evolves. When an athlete encounters a stressful situation, all past stressors, personality traits, and coping strategies influence his or her response to that particular stress (Andersen & Williams, 1988). The researchers deem the stress response to be a two-way relationship between one's cognitive appraisal and their physiologic response (Andersen & Williams, 1998). In the original study, Andersen and Williams (1988) proposed that a heightened response to stress and a limited number of coping strategies increases the risk of sustaining an injury. Another study analyzed 136 injured elite athletes ranging in age from 18-44 participating in 25 contact and noncontact sports throughout their rehabilitation process to examine the psychological aspects that accompany a lengthy rehabilitation process (Fallon & Quinn, 1999). The authors found that vigor steadily increased and tension steadily decreased over the course of recovery while all negative emotions decreased and anger, depression, and confusion were highest during the first of three phases (Fallon & Quinn, 1999). Self-efficacy was defined as "confidence in adhering to their rehabilitation program" and showed no significant difference across time but their confidence of complete recovery diminished over time, which could be attributed to the doctor's immediate diagnosis being given before true extent of injury is known (Fallon & Quinn, 1999). Confusion was found to be highest immediately following injury, suggesting that the athlete was unsure as to the extent of his or her injury and participation status (Fallon & Quinn, 1999).

2.8.2. Psychology of Injury in Sport

When an athlete endures an injury, a cascade of emotional responses follows and can linger throughout the duration of the return-to-play process, into the athlete's career, and long after the days of competitive sports are over and activities of daily living are the norm (Tracey, 2003). A 2003 prospective study examined athletes who incurred moderate to severe injuries to determine the variety of emotional responses experienced throughout the rehabilitation process, which was unlike any previous research (Tracey, 2003). Athletes were interviewed at the time of injury, one week, and three weeks post-injury. The first interview (i.e.,, time of injury) indicated that the severity of the injury was less important at the onset of injury. The emotional responses included anger, depression, confusion, frustration with increased attention, helplessness, and worry (Leddy, Lambert, & Ogles, 1994; Tracey, 2003). Experiencing some shock was a common theme, and participants admitted that they had never considered themselves at risk of injury (Tracey, 2003).

The second interview (i.e.,, one week post-injury) yielded frustrations with a loss of independence, and a focus on the visible characteristics of the injured body part as well as the athletic trainer's response to their progress (Tracey, 2003). Participants also reported putting more time and effort into their academic work since their participation in sport was limited, but they also mentioned a fear of falling behind in their athletic skills and fitness (Tracey, 2003). The athletes also determined that the choice of whether or not to attend practice was torturous for their emotional well-being (Tracey, 2003).

By three weeks post-injury, participants reported an upward swing in their emotions as they progressed toward returning to participation and found ways to work through their emotions with friends and family (Tracey, 2003). Those who had returned to at least partial participation reported a feeling of relief upon being reunited with teammates on the field after being alienated on the sidelines, but the athletes with more serious injury still reported feelings of frustration, disappointment, and discouragement with missing so much competition (Tracey, 2003).

A prospective study followed 343 male collegiate athletes over the course of each athlete's season who completed preseason baseline questionnaires including the Beck Depression Inventory (BDI), the State-Trait Anxiety Inventory-Form Y, and the Tennessee Self-Concept Scale, which were then completed again post-injury and at a follow-up appointment (Leddy, Lambert, & Ogles, 1994). The researchers of this study found the common themes of depression and anxiety among injured athletes immediately after injury, but they also concluded that safely returning athletes to full participation should include both a physical and psychological rehabilitation program (Leddy, Lambert, & Ogles, 1994).

This research suggests that once athletes are considered physically ready to return to play by the medical staff, they face the psychological aspect of preparing themselves to face the competition, which could take a significant amount of time yet (Wiese & Weiss, 1987). Without confidence, athletes have a higher risk of re-injury, new injury, depression, and long-term performance deficits (Wiese & Weiss, 1987). The psychology of injury follows a general trend of frustration and anxiety with the initial injury that turns into acceptance, determination, and confidence upon returning to participation. However, this trend can be affected by a myriad of factors such as a loss of social support, loss of starting position, and lingering discomfort from the injury that makes the athlete question his/her readiness for team activity. Such circumstances could be detrimental to an athlete's confidence upon returning to play. Concussions are specifically problematic in this regard because the nature of the injury lends itself to being taken lightly.

The absence of crutches, braces and bandages makes a concussion a fairly imperceptible injury to outside observers who frequently assume malingering, which can and often does lead to increased pressure on the athlete trying to safely return to play (Kissinger & Johnston, 2005). A study by Wasson interviewed 43 injured athletes and 29 coaches from Division I and II athletic departments who completed the Social Support Survey (SSS) created by Richman, Rosenfeld, and Hardy (1993) that measures the subject's perceptions of eight types of social support (2003). They found that both coaches and injured athletes think emotional support is the most important followed by task appreciation and listening support ranking second and third, respectively (Wasson, 2003). Coaches' responses indicated that their concern for providing social support was greater than the athletes' concern for receiving it, but athletes felt that coaches in general have good intentions of providing support when a player is injured but fail to turn those intentions into actions (Wasson, 2003). All participants reported that women are at a greater need for support after an injury than men and that more severe injuries require an intensified show of support, but athletes who were significantly injured and missed extensive training felt that the support was lost (Wasson, 2003).

A prospective observational study administered the Social Support Questionnaire to 256 DI athletes and found that males reported a greater amount of social support, but females were more satisfied with the support they received. The athletes reported that the amount of social support changed after sustaining an injury (Yang, Peek-Asa, Lowe, Heiden, & Foster, 2010). They found themselves relying more on coaches, physicians, and particularly athletic trainers and less on friends and teammates (Yang, Peek-Asa, Lowe, Heiden, & Foster, 2010).

2.8.3. Psychology of Injury and TBI/Concussion

Not only do concussion and TBI victims struggle to return to sport, but they also face hardship when returning to work, school, and activities of daily living. A comprehensive review of the literature involving the long-term quality of life (QOL) of TBI patients yielded results that raise concern as the victims report a lower QOL score in most categories after injury compared to their pre-injury score and/or control groups (Dijkers, 2004). The literature showed that people who had endured even just a moderate TBI had issues coping at work and were sometimes demoted or even let go due to decreased performance, and unemployment was shown to greatly affect QOL because it has a direct effect on financial stability and material comforts (Hendryx, 1989; Kersel, Marsh, Havill, & Sleigh, 2001; Wagner, Hammond, Sasser, & Wiercisiewski, 2002). Students were seen to be greatly affected because once their immediate graded symptoms subsided, their accommodations were retracted, and they struggled to continue at their pre-injury capabilities (Kersel et al., 2001). Social relationships were also an area of concern due to reports of decreased satisfaction with close relationships, though no study to date has compared TBI patients with a control group to substantiate the findings that a high percentage of people fail to maintain their relationship with their significant other after experiencing a concussion (Webster, Daisley, & King, 1999; Wood & Yurdakul, 1997). A common finding in the literature was leisure disability among TBI patients that prevented them from fully enjoying their free time and often engaging in activities that simply pass the time (Tate, Lulham, Broe, Strettles, & Pfaff, 1989).

When all of these individual categories are considered, the result is a Health-Related QOL (HR-QOL) score most commonly measured with the Medical Outcomes Study 36-Item Short-Form Health Survey (Dijkers, 2004). This survey quantifies physical, social, and role functioning, bodily pain, mental health, vitality, and general health on individual scales and mental and physical health composites on summary scales (Dijkers, 2004). Studies using this tool found that TBI victims reported a lower score in every category compared to their control group or normative data, which indicates worse health (Colantonio, Dawson, & McLellan, 1998; Findler, Cantor, Haddad, Gordon, & Ashman, 2001; Paniak, Phillips, Toller-Lobe, Durand, &

Nagy, 1999). Van der Naalt, Van Zomeren, Sluiter, and Minderhoud (1999) found fatigue to be a frequent complaint even a year post-injury in 45% of cases.

Mainwaring et al. (2009, 2010) conducted a series of studies to compare the emotional responses of musculoskeletal injuries to those of concussed athletes. Fifty-three participants comprised a control group of 19 healthy and physically active undergraduate students, a group of 20 concussed collegiate athletes, and a group of 14 athletes with varying musculoskeletal injuries (Hutchison, Mainwaring, Comper, Richards, & Bisschop, 2009). All participants completed baseline neuropsychological testing, athletes incurring a concussion or musculoskeletal injury completed the post-injury testing within 96 hours of the initial injury and then at one week and two weeks post-injury while the control group completed subsequent testing for two weeks after their initial baseline test (Hutchison, Mainwaring, Comper, Richards, & Bisschop, 2009). The Profile of Mood States (POMS) was the chosen instrument and includes 40 adjectives arranged into seven subscales where participants were asked to mark how they feel 'right now' on a five-point Likert scale from 'not at all' to 'extremely' (Hutchison, Mainwaring, Comper, Richards, & Bisschop, 2009).

Results indicated that pre-injury emotional functioning has no association with post-injury mood. The researchers also found that emotional response after concussion differs from that of musculoskeletal injuries (Hutchison, Mainwaring, Comper, Richards, & Bisschop, 2009). Concussed athletes reported greater fatigue and lack of energy whereas those with musculoskeletal injuries reported increased anger (Hutchison, Mainwaring, Comper, Richards, & Bisschop, 2009). Total mood disturbance remained increased for concussed athletes two weeks post-injury, but the data was variable with high standard deviations, which the researchers suggest is more reason to study individual responses to concussion (Hutchison, Mainwaring, Comper, Richards, & Bisschop, 2009).

A follow-up study prospectively compared collegiate athletes with concussions to those with ACL injuries as well as to an uninjured control group. Their intent was to analyze the emotional sequelae of SRCs compared to another common athletic injury to determine if such responses result from athletic injury in general or if they are specific to concussion (Mainwaring, Hutchison, Bisschop, Comper, & Richards, 2010). Subjects included 16 athletes in the concussion group, seven in the ACL group, and 28 in the control group, and all participants were subjected to pre-season baseline emotional state testing using the POMS and neuropsychological assessment (Mainwaring et al., 2010). The control group underwent serial testing throughout the academic year while concussed and confirmed ACL pathology athletes were scheduled for testing on the day of injury and then on days 4, 8, 15, 22, and 29 when possible, but the ACL subjects were usually delayed in their follow-up visits due to limited mobility (Mainwaring et al., 2010).

Results of this study indicate that emotional responses resulting from general athletic injury are not caused by pre-existing emotional dysfunction and both injury groups showed notable increases in depression scores after injury compared with the controls (Mainwaring et al., 2010). Significant emotional disturbances were reported by both injury groups suggesting that concussions have just as much of an emotional effect as do ACL injuries. Athletes with ACL pathology experience more than seven times the depression 11 days after injury compared to their baseline. At four days post-injury, concussed athletes reported depression three times greater than baseline that diminished within one week of injury (Mainwaring et al., 2010). Methodical patterns of total mood disturbance and depression were exhibited by both injured groups, but limits of this study include the small sample size and the variability in the data (Mainwaring et al., 2010).

The results of the Mainwaring studies indicate that concussed athletes report similar emotional disturbance as athletes suffering from ACL pathology but on a different time line. However, the research is mostly focused on ACL injuries with few studies on SRC. Moreover, Mainwaring et al. (2010) recommended that more research be conducted to investigate which emotional responses stem from psychosocial-behavioral consequences and which are a result of the general injury experience.

2.8.4. Fear of Re-injury Measurement Scales

The fear of returning to play has primarily been analyzed in athletes rehabilitating surgically reconstructed ACL, and several scales have been created to measure the extent of that fear (Langford, Webster, & Feller, 2009; Mohtadi, 1998; Visscher, 2010). The Tampa Scale for Kinesiophobia (TSK) is a self-report questionnaire that is utilized in determining the fear of re-injury due to movement (Visscher, Wilkosz, Wijk, Naeije, & Ohrbach, 2010). It consists of 17 items scored on a 4-point Likert scale ranging from ‘strongly disagree’ (scored as 1) to ‘strongly agree’ (scored as 4) (Visscher et al., 2010). Four of the questions are negatively worded and scored reversely (Visscher et al., 2010). A higher total score suggests an increased fear of movement (Visscher et al., 2010). The TSK was found to specifically measure one’s fear of movement (kinesiophobia) of a specific injured body part rather than the overall fear of reinjuring the structure upon returning to sport (Webster, Feller, & Lambros, 2008). It has been used successfully, particularly in cases of chronic musculoskeletal pain such as osteoarthritis, lumbar pain, and temporomandibular joint dysfunction (Webster et al., 2010). Although kinesiophobia can lead to a greater fear of re-injury, the TSK was dismissed as a viable option for this particular study as its purpose was narrow and lacks validity in acute musculoskeletal injuries.

The Emotional Response of Athletes to Injury Questionnaire (ERAIQ) is a popular scale in sport psychology for measuring one's emotional responses to injury and throughout the rehabilitation process, but it does not specifically consider one's feelings about returning to sport (Langford, Webster, & Feller, 2009). The scale provides subjects with 13 emotions to which they must assign a score (Langford, Webster, & Feller, 2009). The emotions are not specifically linked to sport, so it was decided that this was not the best scale for the proposed study.

A study by Turk, Robinson, Sherman, Burwinkle, and Swanson (2008) assessed the utility of the Pictorial Fear of Activity Scale-Cervical (PFActS-C) which provides a series of contexts in which four movements of biomechanical stress on the neck are depicted: direction of movement, arm position, weight bearing, and extremity of movement. The instrument was tested on 355 car accident victims who were separated into two groups-those sustaining mild injuries and those with moderate to severe injuries, and they were asked to rate their fear of participating in activities involved in the PFActS-C (Turk et al., 2008). The results showed that this instrument could be effective in determining fear in patients with cervical neck pain, but because a concussion encompasses far more complex symptoms that simply neck pain, the researcher decided it would not be an effective tool for this particular study.

The Anterior Cruciate Ligament-Return to Sport Inventory (ACL-RSI) showed promise because it was designed specifically for ACL patients. One study found that three components affected one's fear of re-injury: emotions, confidence in performance, and appraisal of risks (Webster et al., 2008). The emotion component was found through a thorough literature review to find the emotions most commonly reported by rehabilitating athletes (Webster et al., 2008).

Some items from the ACL-RSI were adapted from the ACL-Quality of Life (ACL-QOL) scale presented in a study by Mohtadi (1998) that identified emotions and confidence as factors contributing to one's ability to return to sport after ACL reconstruction (Mohtadi, 1998). Risk appraisal was determined by allowing 28 ACL reconstruction athletes to analyze the questionnaire during validation and make recommendations (Webster et al., 2008). They suggested including a question to allow for expression of fear of undergoing another surgery upon re-injury (Webster et al., 2008). These combined factors were formed into 13 randomly-ordered questions to assess one's fear of re-injury. A 10-centimeter visual analogue scale is presented with each question with the identifier "extremely" at one end of the line and "not at all" at the other end (Webster et al., 2008). The scale was found to have acceptable internal consistency and a varied range of scores as well as a suitable length of time to complete when used clinically and an agreeable format which resulted in no items being left blank when tested among 220 participants (Webster et al., 2008). It was decided that the ACL-RSI would be appropriate for this proposed study with some modifications to concussions.

Researchers have conducted a significant amount of research concerning the fear of returning to sport after ACL reconstruction as that particular injury has become more prevalent among athletes. However, as the number of diagnosed concussions among athletes continues to increase, the literature describing the psychology of returning to play has not followed suit. To the researcher's knowledge, no scale exists that is specific for measuring the fear of returning to sport in athletes who have suffered an SRC, which could be a contributing factor to why the research remains limited in this domain.

2.8.5. Fear of Re-injury in Sport

The fear of re-injury in sport has been most notably studied in people with surgically-reconstructed ACLs and chronic back pain (Crombez, Vlaeyen, Heuts, & Lysens, 1999; Kvist et al., 2005; Langford, Webster, & Feller, 2009; Tripp et al., 2007). Kvist et al. (2005) conducted a study analyzing the factors influencing the return to previous activity in 62 non-athlete patients who had undergone ACL reconstruction. They found that 53% of the subjects returned to their pre-injury level of activity, and those who reported not doing so recorded a higher fear of re-injury score on the TSK and a lower knee-related quality of life (Kvist et al., 2005).

A study was done to determine if the fear of pain was more disabling than the pain itself and if pain-related fear measures are more accurate predictors of behavior performance than general pain level beliefs (Crombez, Vlaeyen, Heuts, & Lysens, 1999). One hundred and four patients with self-reported chronic low back pain were given the TSK, the Pain Anxiety Symptom Scale (PASS), and the Fear-Avoidance Beliefs Questionnaire (FABQ) (Crombez, Vlaeyen, Heuts, & Lysens, 1999). High correlations were found between the pain-related fear measures and self-reported disability and behavioral performance indicating that those who had greater fears of pain and re-injury were more likely to consider themselves somewhat disabled (Crombez, Vlaeyen, Heuts, & Lysens, 1999). The researchers concluded that in these patients with chronic back pain, the fear of pain and re-injury was more disabling than the pain itself.

Langford, Webster, and Feller (2009) studied 87 competitive athletes between the ages of 18 and 40 to determine if their psychological response evolves during the ACL reconstruction rehabilitation process and if such responses affect the return to sport. All subjects completed both the ERAIQ and the ACL-RSI at 3, 6, and 12 months post-surgery (Langford, Webster, & Feller, 2009). After 12 months, 51% of the subjects had returned to their sport. No differences were noted in physical recovery or ERAIQ scores between returners and non-returners, but those athletes who had returned to sport scored higher on the ACL-RSI than their non-returning counterparts (Langford, Webster, & Feller, 2009).

To investigate fear of re-injury, negative affect, and pain catastrophizing as they relate to an athlete's confidence in returning to sport one year after undergoing ACL reconstruction surgery, Tripp et al. (2007) conducted a study with 49 recreational athletes. All participants completed demographic, pain, return to sport, and psychological indexes including the TSK and a shortened version of the POMS during one session (Tripp et al., 2007). The results indicated that negative affect was the single significant predictor of decreased sport confidence. Negative affect and fear of re-injury were inversely associated with sport confidence and reported return to sport, respectively. The researchers concluded that an athlete's confidence in returning to sport is reduced in those exhibiting an increased negative mood and greater fear of re-injury (Tripp et al., 2007).

In one of the only studies to examined fear of re-injury to sport participation in all injuries, Covassin et al. (2015) determined the relationship between time-loss from injury and fear of return to participation. A total of 525 injuries diagnosed by a physician and/or athletic trainer were represented in this study. Athletes completed a baseline and post-test survey approximately one week after returning to sport participation. Athletes rated their fear of returning to sport and re-injury on a Likert-scale from 0 (i.e.,, no fear) to 10 (i.e.,, greatest fear). Each injury was classified into one of three levels of severity based on time-loss from sport participation. Injuries were classified as "minor" for time loss less than one week (< seven days), "moderate" for time loss of one to three weeks (7-21 days), and ''major'' for time loss greater than three weeks, respectively (Powell & Barber-Foss, 1999). The study found athletes who incurred major injuries resulted in significantly more fear of returning to sport and fear of re-injury than injured athletes with minor injuries. Almost one quarter of injuries (23.7%) produced a moderate to severe fear of re-injury with 14% of injuries producing a moderate or severe fear of returning to sport.

The results from these studies are especially concerning to the athletic population who accept risk each day they train in their particular sport. If athletes are aware of the potential long-term effects of mild traumatic brain injuries, the thought of worsened health during their later years could be lingering in the back of their minds when they return to sport. Such thoughts could affect their level of play due to hesitation or a lack of confidence that their head will be able to endure another potential hit without long-lasting effects. This study aims to address whether or not that fear exists in collegiate athletes who have sustained a concussion and have returned to play.

2.9. SUMMARY

This review of the literature reveals that the current available research is lacking studies concerning the potential fear concussed athletes feel when they are deemed ready to return to play. Athletes who have undergone ACL reconstruction or who suffer from chronic back pain have been adequately studied, and such athletes have been found to experience a fear of enduring another injury, but the research needs to expand to include a more broad scope of injuries. This study hopes to aid in determining the extent of that fear of re-injury.

This study makes an effort to expand the existing fear or re-injury literature to include athletes who have sustained an SRC. The basis of this research is that athletes with other musculoskeletal injuries have been found to experience fear when returning to their sport (Kvist et al., 2005; Crombez, Vlaeyen, Heuts, & Lysens, 1999). Mainwaring et al. (2010) and

Hutchinson et al. (2009) found that similar emotional responses exist between athletes with musculoskeletal injuries and those with concussions. Long-lasting effects have also been associated with brain injury and that knowledge could be in the forefront of an athlete's mind when they return to play after sufficient rest and rehabilitation. Therefore, this study will investigate the extent of the fear of re-injury, if any, that recovered concussed collegiate athletes experience upon returning to participation.

CHAPTER 3

METHODS

3.1. PURPOSE

The purpose of this study was to explore the psychological responses associated with returning to play in collegiate student-athletes who had sustained a sport-related concussion within the past three months. This chapter will discuss the research design, participants, including inclusionary and exclusionary criteria, instrumentation used for this study, procedures and data analysis.

3.2. RESEARCH DESIGN

This was a retrospective, survey-based study approved by the Michigan State University Institutional Review Board (IRB). Participants were emailed a link to an online survey to be completed after they had returned to play following an SRC. The single-survey, retrospective nature of this study eased data collection and followed the design of previous research conducted in this realm. It also provided a starting point for future research in this area.

3.3. SAMPLE POPULATION AND PARTICIPANT SELECTION

Thirty-three participants who sustained an SRC during participation in their respective collegiate sport for the period of time between March 2015 and January 2016 were asked to volunteer for this study. Inclusion criteria included male and female collegiate athletes who sustained a sport-related concussion confirmed by a health care professional using specific diagnostic criteria. Criteria included a known mechanism of injury, self-reported symptoms of loss of consciousness, headache, dizziness, nausea, confusion, amnesia, imbalance, attention issues, behavioral changes, depression, irritability, cognitive impairments, decreased reaction time, balance deficits, or any combination thereof (McCrory et al., 2013). Athletes must also have returned to full participation in their given sport within the past three months prior to the beginning of data collection. Those with a history of migraines, diagnosed learning disability, cognitive disability, or psychological disorder were also included. Exclusion criteria included anyone who had not yet returned to full participation in their sport and anyone whose concussion was not sustained during sport-related activity. Subjects with a loss of consciousness of more than five minutes after injury were excluded.

3.4. INSTRUMENTATION

The instrumentation for this research began with an informed consent explaining to the athletes the format of the survey and asking for voluntary consent. The subsequent pages included a survey, a series of demographic questions, and a brief concussion history section.

The ACL-RSI was validated in a demographic of active males and females between the ages of 16 and 54 who had undergone ACL reconstruction to analyze the psychological impact of returning to sport (Webster et al., 2008). The ACL-RSI consists of three sections of highly-related questions, or outcome measures, related to the psychology of returning to sport: emotions, confidence in performance, and risk appraisal (Webster et al., 2008). A literature review of the current research identified common emotional responses to injury when one is returning to sport participation to be fear of re-injury, frustration, nervousness, and tension, and these concepts were used to develop the first five questions of the inventory (Webster et al., 2008). The first question measures nervousness, Question two relates to frustration, Question three is geared toward identifying tension, and the remaining two questions target the fear of re-injury both during sport and in daily life (Webster et al., 2008).

The middle third of the survey focuses on sport confidence with three questions assessing athlete’s confidence in their knee’s functionality and two items measuring their confidence in their general ability to perform adequately in their sport (Webster et al., 2008). Originally, only a single question was included to assess the risk appraisal of the participant, but a trial consisting of 28 athletes with a reconstructed ACL was conducted, and suggestions by the participants were used to add one more question.

Webster et al. (2008) found the means to range from 50.93 to 73.1 out of a possible score range of 0-120 with large standard deviations, which was deemed preferable properties of scale items. The lowest-scoring items were those assessing frustration, fear, nervousness, and risk appraisal, and the items scoring the highest were those involving confidence in sport performance, which was consistent with the existing literature (Webster et al., 2008). The questions regarding more positive emotions (i.e., Questions 1, 4, 5, 8, 11, 12) were then reverse-scored so all questions in the scale would be consistent. When the results were analyzed, Cronbach's alpha was 0.96, and the mean inter-item correlation was 0.69 which signified high internal consistency and inter-item correlation (Webster et al., 2008). Deleting any individual item did not notably increase or decrease the coefficient alpha (Webster et al., 2008). An eigenvalue of 8.14 confirmed the existence of one underlying factor in a principal components analysis, which accounted for 67.8% of the total variance (Webster et al., 2008). The total score was found by adding the individual scores of all 12 items and finding the average (Webster et al., 2008). The 12 items were then given a random order, and each item included a 10cm Visual Analogue Scale ranging from "extremely" to "not at all" where participants were asked to indicate where on the line best represented their feelings for that particular question (Webster et al., 2008). The original questions can be found in Appendix A.

Webster et al. (2008) determined that the ACL-RSI could be adapted to fit other sports-related injuries so the questions of the scale were adjusted to fit a demographic of concussed athletes for the purposes of this study. This revised Sports-Related Concussion Return to Sport Inventory (SRC-RSI) can be found in Appendix B.

A demographic portion consisting of questions asking about age, sex, race, height, weight, sport, and years of participation was included. A concussion history section was also included and asked questions regarding the number of previously sustained concussions, existence of treatment for cognitive conditions, and history of diagnosed neurocognitive disorders. This section included the date that the most recent concussion was sustained, a brief description of how it occurred, and the health care professional who diagnosed it as a concussion. The demographic questions can be found in Appendix C.

Qualtrics® was used to create the survey to be completed by each athlete in the study. The title of the survey distributed to participants was "The Survey of Sport Participation Following Concussion" so subjects would have a general idea as to the scope of the study without providing too much information that would allow opportunity for bias (Webster et al., 2008).

Separate multinomial logistic regressions were performed on the dependent variables (i.e.,, emotion, risk, confidence) and independent variables (i.e.,, sex, sport) to determine if there was an association between sex and sport and psychological responses in collegiate athletes who incurred an SRC.

3.5. DATA COLLECTION AND MANAGEMENT

Colleges from all three NCAA divisions were asked to participate in this study before data collection began. Head athletic trainers' email addresses were found on each school's athletics website and used to make initial contact. Schools who consented to participation included the University of Denver, Saginaw Valley State University, Lake Superior State

University, Tiffin University, Wayne State University, Carroll University, and Mercyhurst University. Upon proposal approval, each athletic trainer was given notification of IRB approval and sent an online link to the adapted ACL-RSI via email. The head athletic trainer at each institution was asked to send the link to each athlete who had returned to play after sustaining an SRC. Athletes who had sustained a concussion in the three months prior to the beginning of data collection and had already returned to play were also included. Head athletic trainers were contacted every two weeks to identify new potential participants. Upon completion, the athletes electronically submitted the consent form and survey to the researcher. None of the collected data contained any identifying information, and each completed survey was given a unique identification number upon receipt. Completed surveys were stored on the Qualtrics® software where only the researcher was able to obtain them with a username and password. All head athletic trainers were notified on February 1, 2016 that the data collection phase had been completed.

3.6. DATA ANALYSIS

Demographic information was summarized using descriptive data. The ACL-RSI consisted of three sections of questions related to the psychology of returning to sport: emotions, confidence in performance, and risk appraisal. The means and standard deviations were obtained for all questions on the ACL-RSI. Athletes received three individual scores for each of the three sections. A higher number represented an elevated psychological response and a lower number represented a lessened psychological response for the emotion and risk categories. Since the confidence grouping of questions were reverse-scored, a lower score indicated an elevated confidence level and vice versa. Scores over a five indicated a greater fear of re-injury. To answer the research question if collegiate athletes had a greater fear of re-injury, athletes who scored over an average of five (i.e.,, total score of 60+) were considered to report a greater fear of re-injury compared to those who scored an average of less than five. A step-wise analysis was going to be used to describe the exploratory variables of time-loss, gender, and sport, but the small number of participants rendered such calculations ineffective. The Statistical Package for the Social Sciences (SPSS) (22.0) software was used to statistically analyze all data.

CHAPTER 4

RESULTS

4.1. DEMOGRAPHICS

Thirty-five participants took part in the survey, but two of the participants only opened the survey and did not answer any questions so their responses were discarded. Therefore, 33 completed surveys were used for data collection and analysis. Of the 33 participants, 20 were male and 13 were female. The average age of the male participants was 19.7 ± 1.19 years. The average height was 72.5 ± 2.8 inches and the average weight reported was 228.2 ± 42.2 pounds. Sixteen of the male subjects declared being white, one declared Hispanic descent, one black, and one checked the mixed race option. Five of the participants were freshman, five were sophomores, five were juniors, and five were seniors.

Thirteen of the participants were female with an average age of 19.0 ± 0.88 years. The average height of the female participants was 65.5 ± 2.2inches, and the average weight was 135.1 ± 13.9 pounds. In terms of ethnic descent, 10 female participants reported being white, one reported being black, and one reported being of a mixed race. Five were freshman, five were sophomores, two were juniors and one reported being a senior in class status.

In the male demographic, the most common sport was football with 18 participants participating. One participant was a member of the school’s lacrosse team and one participated played ice hockey. For the football players, 13 participants reported playing offense and five primarily played defense. Of those 18 participants, three reported specifically playing on the offensive or defensive line. The lacrosse player was a defender and the ice hockey player reported playing an offensive position. The average years of participation in their current sport was 10.1 ± 3.4 years.

Female subjects participated in rowing (1), diving (3), soccer (7), and lacrosse (2). For specific positions, four of the soccer players played defense, two played midfield, and one played the forward position. The lacrosse players were split with one playing defense and one playing midfield. The average years of participation was 10.8 ± 5.2 years.

When asked about his or her concussion history, nine males and six females reported experiencing a previous concussion diagnosed by a medical professional. For the remaining 18 participants, his or her current concussion when taking the survey was the first. Three participants reported two previously diagnosed concussions. Two participants reported three previously diagnosed concussions. Ten participants reported one previously diagnosed concussion. The average number of days missed from practice for males was 12.9 ± 8.0 days, and the average days missed for females was 10.8 ± 8.9 days.

Ten of the participants (five male, five female) reported receiving medical treatment for headaches in the past. Five of those participants had experienced at least one concussion prior to his or her current concussion. One female participant had previously received treatment for both headaches and migraines and one male participant had received medical treatment for just migraines. Both of these participants had one previous concussion. One female participant had previous treatment for meningitis. Two female participants had previous treatment for a psychiatric condition. Six participants (three male, three female) reported a learning disorder diagnosis and one female reported attending special education classes. Four female and one male participant reported being diagnosed with depression or anxiety.

4.2. OVERVIEW OF SURVEY RESULTS

For the next section, the responses for each of the three outcome measures and all of the related questions will be discussed. (See Tables 1-5 in Appendix D).

4.2.1. Emotion Results

The average response among participants for the five emotion questions was 4.64±2.21. Despite the average, 36.4% of the participants had an average emotional score below 5.00. The first question of the survey was aimed at finding out if participants were nervous about playing his or her support post-concussion. Approximately one-fifth (20.6%) of participants reported that they do not feel nervous at all about playing their sport and 65.5% answered below four. The average response was 3.45 ± 3.19. (See Table 1 in Appendix D).

The second question asked participants if he or she found it frustrating to have endured a concussion while trying to play his or her sport. Approximately one-third (64.5% 20/31) marked an eight or higher with the average response being 7.47 ± 3.02 (See Table 2 in Appendix D). The third question asked about each participant's feeling of relaxation while playing his or her sport. This was a reverse-scored question due to the positive emotion being measured; therefore, a lower score was considered preferable. The average response was 2.67 ± 2.75. Twelve of the 33 participants (36.4%) responded with 'extremely' (See Table 3 in Appendix D).

Question four concerned the fear participants felt in regards to sustaining another concussion during their sport. The average response was 5.1 ± 3.14 (See Table 4 in Appendix D). The final question in the emotion section of the survey asked athletes if they were fearful of accidentally injuring their brain or head while playing their sport. The average response of the participants was 5.20 ± 3.45 (See Table 5 in Appendix D).

4.2.2. Confidence in Sport Performance Results

The questions in this section asked about an athlete's confidence in sport performance. These questions were all reverse-scored to maintain consistency throughout the survey. Therefore, the average score for confidence was the lowest of the three outcomes measures at 2.81±2.25. (See Tables 6-10 in Appendix D). Question 6 explored each participant's confidence that his or her symptoms would not return and cause issues during sport participation. The average response was 3.55 ± 3.14 (See Table 6 in Appendix D).

Question 7 aimed to measure the extent of the confidence athletes felt regarding returning to play without concern for his or her concussion. Th**e** average response was 3.73 ± 3.14 with almost a quarter (24.2%) of participants feeling extremely confident (See Table 7 in Appendix D). Question 8 asked participants if they were confident that their brain or head would function normally during the stressful situations that could arise during their sport. The average response was 1.88 ± 2.10 with 37.5% answering with 'completely confident. Almost 60% (59.38%) responded with a nine or ten (See Table 8 in Appendix D).

The ninth questioned asked athletes if they were confident they could perform at their pre-concussion level. Participants reported a mean of 2.91 ± 2.92, with two-thirds of athletes reporting an 8 or higher out of 10 (21/33 = 63.6%) (See Table 9 in Appendix D). The final question inquired about the confidence level of each participant's ability to perform his or her sport well. The average response was calculated to be 2.06 ± 2.37, and 39.4% of the participants marked 'extremely' (See Table 10 in Appendix D).

4.2.3. Risk Appraisal Results

Questions 11 and 12 identified any concern for future risk or injury. The average response was 3.38±2.44. (See Tables 11 and 12 in Appendix D). Question eleven asked athletes if they thought they were likely to sustain another concussion playing in their particular sport. Results indicated that the average response was 4.58 ± 3.27. Almost 42% of participants responded with a four or lower (See Table 11 in Appendix D). Question 12 asked participants if thoughts of having to go through the concussion recovery process prevented them from playing their sport. The average response was 2.10 ± 3.19 and half the participants (14/28) answered ‘not at all’ (See Table 12 in Appendix D).

4.2.4. Exploratory Question Results

The last six questions were exploratory questions added by the researcher. Question 13 asked athletes about their concern regarding enduring another concussion. The average response was 4.96 ± 3.13 (See Table 13 in Appendix D). Question 14 asked each participant about the likelihood that he or she would give up playing his or her sport due to concerns about concussions. The average response was 2.96 ± 3.82 with 50% of the participants replying with ‘not at all’ (See Table 14 in Appendix D).

Question 15 inquired about any concerns over the long-term consequences of concussions. The average response was 4.59 ± 3.65 (See Table 15 in Appendix D). Question 16 asked participants if they felt they had altered their style of play due to their concussion. The average response amongst participants was 2.48 ± 3.37 with 72% of all responding participants responding with two or lower (See Table 16 in Appendix D).Question 17 asked participants if they were hesitant to return to practice post-concussion. The average response was 3.96 ± 3.14 (See Table 17 in Appendix D).The 18th and final question asked athletes if they were hesitant to return to game participation after their concussion. The average response was 3.46 ± 3.05 (See Table 18 in Appendix D).

4.3. ASSESSMENT OF RESEARCH QUESTIONS

What is the level of the psychological responses in confidence, emotion and risk in athletes with a sport-related concussion?

When examining the three components of the psychological response survey, the average score for the five confidence items was 2.81 $\pm$ 2.25, and 4.64 $\pm$ 2.21 and 3.38 $\pm$ 2.44 for the emotional items and risk items, respectively. Tables 19-21 found in Appendix E illustrate a frequency breakdown of the emotion, risk, and confidence average scores per participant and help identify instances where higher numbers of participants marked the same numbers and skewed the average slightly. For instance, only 36.4% of participants had an average emotional score on the bottom half of the scale which skews the data toward the upper end of the range. In Table 20 which included the scores for the risk average, 26 of the 31 participants fell below 5.00. Moreover, the risk average is drastically skewed toward the lower end of the range. In the confidence category, the average score for participants appeared to be evenly distributed until 5 people averaged a score of 0 when reverse-scored which shifted the data. By these standards, participants exhibited an elevated psychological response regarding confidence because the questions are reverse-scored so a lower average represents a greater confidence. For the outcome measure of risk, the average response was low, which suggests that participants did not feel an exacerbated risk of further injury at the time they took the survey. Since the average response in the emotional category was also below 5.0, the results suggest that no elevated emotional response when returning to play after an SRC exists. In conclusion, the results show that athletes exhibit a high level of confidence, a low concern for risk, and no notable elevated emotional response when returning to full participation after sustaining an SRC.

Are there sex differences in level of psychological response in confidence, emotion and risk in athletes with a sport-related concussion?

To determine if sex differences exist in the level of psychological response when returning to sport participation after an SRC, t-tests were conducted. There were no significant differences between sex for emotion $t_{(1,31)}$ =1.57, p=.13, d=0.57, risk $t_{(1,29)}$ = 1.74, p=.09, d=0.64 and confidence $t_{(1,31)}$ = 0.55, p=.59, d=0.20.

CHAPTER 5

DISCUSSION

5.1. OVERVIEW

The findings of the current study indicated that athletes have a high confidence level after returning to participation from a SRC. The results also indicated that athletes are not as concerned about the risk of returning to their sport due to their lack of an elevated psychological response. The average emotional response of 4.64 suggests that returning to play following an SRC does not trigger an exacerbated emotional response amongst collegiate athletes. The results of this study also indicated that there were no sex differences on the level of psychological response.

5.2. PSYCHOLOGICAL RESPONSE TO SPORT-RELATED CONCUSSION

The non-significant heightened emotional response elicited by the participants in this study suggests that athletes recovering from an SRC are not experiencing an emotional response different from any other sports-related injury. These results differ from the emotional and behavior response that Morrey, Wiese-bjornstal, Shaffer, and Smith identified in 1998 while studying how athletes react to injury and how that response affects their recovery. Kissinger and Johnston (2005) suggested that an elevated emotional response when recovering from a concussion could be attributed to a concussion lacking the usual signs of injury (i.e., crutches, bandages, etc.) which often causes internal turmoil for the concussed athlete as well as feelings of isolation. The results of this study offer a counter argument that the lack of visible signs of injury with concussions also cause a lack of visibly heightened emotions. Perhaps lacking the stereotypical attributes of injury causes athletes to more quickly return to an average level of emotions.

The lessened emotional response the participants demonstrated could be caused by the unique nature of concussion recovery for athletes. Often times, athletes feel back to normal early on in the step-wise progression and go through the motions of the progression in its entirety before returning to full participation just to follow protocol whereas in other injuries (i.e., ACL reconstruction) the rehabilitation is crucial for strengthening and conditioning the body so it can effectively participate once again.

It should be noted that though the average response was lower than the 5.0 threshold for significance set by the creators of this survey, it was not far from being high enough to be of concern. This result should not be forgotten in a discussion regarding the psychological response being exhibited by athletes returning to play after an SRC. Moreover, five of the six questions included in the emotion outcome measure addressed emotions that would be considered negative when returning to play, and the participants did not demonstrate a heightened response. Such a response coincides with the heightened response the participants displayed in confidence in sport performance outcome measure. It is logical that athletes who score low on negative emotions would score high on questions regarding confidence.

The high confidence levels of these athletes when returning to play could also be attributed to the previously mentioned feelings of wellness early on in the healing process that takes place after a concussion. If an athlete is not experiencing any signs or symptoms of abnormality regarding his/her concussion, it is likely that he/she will enter full participation exhibiting high levels of confidence. The lack of lingering scarring, bandaging, and other physical signs of injury can lead athletes to feel a high level of confidence. These results coincide with the research conducted by Fallon and Quinn (1999) who specifically found that an athlete’s vigor steadily increased over the recovery process.

The lack of concern for any risk of further injury when returning to play that the participants in this study demonstrated is not unlike the participants in the studies analyzing ACL reconstruction patients returning to sport participation. The relationship between high confidence and low concern for risk exhibited in the results of this study agree with the findings of Tripp et al. (2007) where researchers concluded that an athlete's confidence beliefs regarding their return to sport was inversely related to their fear of re-injury. The athletes in the current study who reported a low fear of re-injury when returning to full participation in the emotion section of the survey, also reported feeling confident in their ability to perform the tasks related to their sport.

The low level of perceived risk could be related to this abundant confidence. A lack of risk identification could be attributed to the culture of athletics. Most athletes have likely sustained some type of injury at some point in their career and are well-acclimated to returning to play. An athlete who has previously sustained an injury and successfully returned to full sport participation may not identify as much risk in a similar return to play scenario. A lack of education on the potential severity of a subsequent concussion could be a contributing factor as well.

The high levels of confidence of athletes returning to play after an SRC made evident by the results of this survey agree with some of the previous literature analyzing the psychological aspects of returning to sport. The inverse relationship then between confidence and risk appraisal and emotional frustration follows a similar pattern also demonstrated in previous research. These results suggest that the sports medicine professionals working with these athletes should be prepared to help athletes balance their confidence with the reality of potential risk while monitoring their emotions to be sure that they don't reach a level high enough to affect the recovery process.

5.3. CLINICAL IMPLICATIONS OF FINDINGS

The findings of these studies could help sports medicine professionals better understand the thought process of athletes returning to play after sustaining a sport-related concussion. When helping these athletes return to full participation, a plan to help offset the heightened emotional reaction that some athletes may demonstrate could benefit them and their return to play progression. Recommending a psychologist with whom athletes can discuss their emotional state could benefit their recovery and return to sport, but first and foremost, it could assist them in enduring the struggle of being removed from participation for an injury that is not typically seen by athletes as serious.

Understanding the psyche of an athlete returning to play after an SRC can provide a guideline for the sports medicine team by outlining the role such individuals have to play in order to protect the athlete from not only their injury, but also themselves. This understanding can lead to more specific psychological care provided to the athlete throughout the recovery process by helping them manage their psychological reactions to their concussion.

The results suggest that the recovery process for these previously concussed athletes has a definite psychological component concerning one's level of confidence. The high level of confidence that these athletes demonstrated in their survey responses poses a possible area of concern for sports medicine professionals, but specifically athletic trainers who are with the athletes every practice. Having a high level of confidence as an athlete is important for performing well. Knowing that athletes returning to play after a concussion are highly confident should put athletic trainers on high alert so they do not allow them to participate before they are truly ready based on the protocols and guidelines put in place by the governing bodies. The athletic trainer must be the cautious one since the athletes are demonstrating no lack of confidence in their abilities.

The minimal psychological reaction to regarding the risk of injury with sport-related concussion can put the sports medicine team in a tricky situation. No sports medicine professional wants an athlete on the field preoccupied with concern for the risk of a subsequent injury of life-long implications. On the other hand, the importance of the athlete understanding the significance of his or her concussion and the potential irreversible damage he or she could incur is vital to the athlete making informed decisions about his or her desire to continue participation (Guskiewicz, 2003; 2005). Providing a team doctor with whom the athletes can have honest conversations about their concussion could be a potential solution to this dilemma.

5.4. LIMITATIONS

This study was not without flaws. Thirty-three participants were involved, and not all of them answered every survey question from the adapted ACL-RSI. This along with a limited time span of data collection notably limited the amount of data collected and the significance of the results. With only six months of gathering data, the most intensive time of training for several sports was left out, such as men's ice hockey, which typically sees a large number of concussions. A minimum of one full academic year for data collection could greatly improve the number and variance of the subjects.

The majority (n=18) of the limited amount of participants were male and played football. The mentality of a sport can impact the results of this survey. Football players could respond differently than female athletes, and even other male athletes, due to the nature of the game. Also, most of the NCAA sports were not represented in this study because of the previously mentioned limited amount of participants and time frame for data collection.

The online format of this survey could be considered a limitation due to the inability to personally approach athletes and ask them to complete the survey in person. Athletes were emailed the link and then left to do with it what they pleased. Having the availability to travel to the participating schools and personally touch base with athletes and answer any questions could improve the number of concussed athletes who actually sit down to complete the survey, as well as increase the number of questions they actually answer.

The ACL-RSI was adapted for this study to fit the nature of SRCs. Some of the questions were awkwardly worded when transitioned to concussions and could have confused participants in terms of meaning. Replacing the word ‘knee’ with ‘head/brain’ to make the questions relevant could have caused some confusion as a couple of questions lacked clarity.

The time frame during the recovery process when participants were allowed to complete the survey was variable and allowed for a three month window from the time of the concussion to the time of completing the survey. Some participating athletes had been returned to play for two months before completing the survey and others took it the first day of full participation. This inconsistency could have affected how athletes felt about their concussion at the time of survey completion.

5.5. FUTURE RESEARCH CONSIDERATIONS

This study was only a brief introduction to the extensive amount of research that could be conducted in this area. The adapted ACL-RSI used for this survey could pave the way for a similar scale to be developed specifically for SRCs. Further field testing could help produce and test out questions more specific to the unique nature of these concussions; thus, improving the clarity of the responses. The six exploratory questions added to the end of the adapted ACL-RSI in this study could be expanded upon and used to shape further research.

As discussed in the limitations section, future researchers should consider expanding the time of data collection to include the seasons of all NCAA sports. With more participants, the data could be divided into categories specifying sports, sex, and NCAA division level to identify any key differences that may exist amongst the varying demographics. The data could also be divided to explore the variance in responses of people with differing histories of SRCs. Those responses of participants reporting multiple previous concussions could be compared to those with no previous history to determine if the psychological response changes with increased frequency of injury. Furthermore, a longitudinal study could take place where athletes take the survey after each successive concussion endured and all of that athlete's responses are analyzed against each other.

Standardizing the day in the recovery process the survey is taken would improve the quality of the results. If each athlete were asked to complete the survey the exact day they return to full participation, the responses could be more accurately compared than when some surveys are completed on the day of sport return while others are taken long after their return to participation.

5.6. CONCLUSION

This research study was only the beginning of what could potentially be an extensive amount of research revolving around the psychological healing process that accompanies the physical healing associated with SRCs in collegiate athletes. This preliminary data suggests that athletes show a heightened level of confidence, but a low concern for risk and no notably elevated emotional response when returning to play. If further research continues to show a similar phenomenon, the information could be used to help athletes through any potential emotional stress of recovery while focusing on curtailing their confidence when returning to sport and also helping them understand the potential risk of sport participation after enduring an SRC.

APPENDICES

APPENDIX A

Anterior Cruciate Ligament-Return to Sport Inventory (ACL-RSI)

Emotions

1. Are you nervous about playing your sport? (3)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

2. Do you find it frustrating to have to consider your knee with respect to your sport? (6)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

3. Do you feel relaxed about playing your sport? (12)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

4. Are you fearful of re-injuring your knee by playing your sport? (7)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

5. Are you afraid of accidentally injuring your knee by playing your sport? (9)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

Confidence in performance

6. Are you confident that your knee will not give way by playing your sport? (4)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

7. Are you confident that you could play your sport without concern for your knee? (5)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

8. Are your confident about your knee holding up under pressure? (8)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

9. Are you confident that you can perform at your previous level of sport participation? (1)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

10. Are you confident about your ability to perform well at your sport? (11)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

Risk appraisal

11. Do you think you are likely to re-injure your knee by participating in your sport? (2)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

12. Do thoughts of having to go through surgery and rehabilitation again prevent you from playing your sport? (10)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

Webster, Feller, & Lambrose, 2008

APPENDIX B

The Survey of Sport Participation Following Concussion

For each question, please place a circle on the line below to indicate the extent of your feelings for the following scenario:

"When you first returned to play after your most recent concussion…"

Emotions

1. Were you nervous about playing your sport due to your concussion? (3)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all   Extremely

2. Did you find it frustrating to have sustained a concussion with respect to your sport? (6)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all   Extremely

3. Did you feel relaxed about playing your sport? (12)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all   Extremely

4. Were you fearful of sustaining another concussion while playing your sport? (7)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all   Extremely

5. Were you afraid of accidentally injuring your brain/head when playing your sport? (9)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all   Extremely

Confidence in Performance

6. Were you confident that your concussion symptoms would not return and cause you issues while playing your sport? (4)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all   Extremely

7. Were you confident that you could play your sport without concern for your recent concussion? (5)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

8. Were you confident that your brain/head would function normally during stressful sport situations? (8)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

9. Were you confident that you could perform at your pre-concussion level of sport participation? (1)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

10. Were you confident about your ability to perform well at your sport? (11)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

Risk appraisal

11. Did you think you were likely to sustain another concussion by participating in your sport? (2)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

12. Did thoughts of having to go through the concussion recovery process again prevent you from playing your sport? (10)

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

Extra Questions

13. Were you concerned about getting another concussion?

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

14. Are you likely to consider giving up your sport due to concerns about concussions?

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

15. Are you worried about any long-term consequences of concussions?

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

16. Have you altered your style of play because of your recent concussion?

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

17. Were you hesitant to return to practice activities following your concussion?

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

18. Were you hesitant to return to game participation following your concussion?

[-----|-------|-------|------|-------|------|-------|------|-------|-------]
Not at all Extremely

Adapted from Webster, Feller, & Lambrose, 2008

APPENDIX C

Demographic Survey

Sex: Male______ Female_____
Age: ___________ Year in School: ___________________
Height: ________________ Weight: ________________

Race or ethnicity:

- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Hispanic or Latino
- ☐ Native Hawaiian or Pacific Islander
- ☐ White
- ☐ Other
- ☐ I prefer not to answer

Sport currently playing: ________________________________

Position in current sport: ________________________________

Years of experience in sport at the Collegiate level: ______________________

How many concussions have you previously experienced that were diagnosed by a medical professional? ______________________

What was the date of your most recent concussion? _______________________

How many days were you out of sport participation? _______________________

What was the date you returned to full participation? _______________________

Indicate whether you have experienced the following:

- ☐ Treatment for headaches by physician
- ☐ Treatment for migraine headaches by physician
- ☐ Treatment for epilepsy/seizures
- ☐ Treatment for brain surgery
- ☐ Treatment for meningitis

Have you ever been diagnosed with any of the following conditions?

- ☐ ADD/ADHD
- ☐ Dyslexia
- ☐ Learning Disability
- ☐ Autism

APPENDIX D

Survey Response Results

Emotions

Table 1: Question 1

Response	**N (29)**	**Percent**
0 – not at all	6	20.7%
1	5	17.2%
2	2	6.9%
3	6	20.7%
4	0	0.0%
5	3	10.3%
6	1	3.4%
7	2	6.9%
8	1	3.4%
9	0	0.0%
10 - extremely	3	10.3%

Table 2: Question 2

Response	**N (31)**	**Percent**
0 – not at all	1	3.2%
1	2	6.5%
2	1	3.2%
3	0	0.0%
4	0	0.0%
5	3	9.7%
6	2	6.5%
7	1	3.2%
8	5	16.1%
9	4	12.9%
10 - extremely	11	35.5%

Table 3: Question 3

Response	N (33)	Percent
0 – not at all	1	3.0%
1	0	0%
2	1	3.0%
3	2	6.1%
4	2	6.1%
5	2	6.1%
6	2	6.1%
7	6	18.2%
8	3	9.1%
9	2	6.1%
10 - extremely	12	36.4%

Table 4: Question 4

Response	**N (30)**	**Percent**
0 – not at all	3	10%
1	2	6.7%
2	2	6.7%
3	2	6.7%
4	3	10%
5	4	13.3%
6	4	13.3%
7	1	3.3%
8	3	10%
9	1	3.3%
10 - extremely	4	13.3%

Table 5: Question 5

Response	N (30)	Percent
0 – not at all	5	16.7%
1	1	3.3%
2	2	6.7%
3	2	6.7%
4	3	10.0%
5	1	3.3%
6	5	16.7%
7	2	6.7%
8	2	6.7%
9	2	16.7%
10 - extremely	5	16.7%

Confidence in Performance

Table 6: Question 6

Response	N (33)	Percent
0 – not at all	3	9.0%
1	0	0.0%
2	2	6.1%
3	1	3.0%
4	3	9.1%
5	4	12.1%
6	0	0.0%
7	4	12.1%
8	4	12.1%
9	6	18.2%
10 - extremely	5	15.2%

Table 7: Question 7

Response	**N (33)**	**Percent**
0 – not at all	2	6.1%
1	1	3.0%
2	2	6.1%
3	3	9.1%
4	0	0.0%
5	5	15.2%
6	4	12.1%
7	3	9.1%
8	2	6.1%
9	3	9.1%
10 - extremely	8	24.2%

Table 8: Question 8

Response	**N (32)**	**Percent**
0 – not at all	0	0.0%
1	0	0.0%
2	0	0.0%
3	1	3.1%
4	1	3.1%
5	4	12.5%
6	2	6.3%
7	2	6.3%
8	3	9.4%
9	7	21.9%
10 - extremely	12	37.5%

Table 9: Question 9

Response	**N(33)**	**Percent**
0 – not at all	2	6.1%
1	1	3.0%
2	0	0.0%
3	1	3.0%
4	3	9.1%
5	2	6.1%
6	1	3.0%
7	2	6.1%
8	8	24.2%
9	6	18.2%
10 - extremely	7	21.2%

Table 10: Question 10

Response	**N (33)**	**Percent**
0 – not at all	1	3.0%
1	0	0.0%
2	0	0.0%
3	0	0.0%
4	1	3.0%
5	3	9.1%
6	3	9.1%
7	6	18.2%
8	2	6.1%
9	3	9.1%
10 - extremely	13	39.4%

Risk Appraisal

Table 11: Question 11

Response	**N (31)**	**Percent**
0 – not at all	4	13%
1	4	13%
2	4	13%
3	1	3.2%
4	2	6.4%
5	2	6.4%
6	3	9.6%
7	2	6.4%
8	6	9.4%
9	1	3.2%
10 - extremely	2	6.4%

Table 12: Question 12

Response	**N (28)**	**Percent**
0 – not at all	14	50.0%
1	4	14.3%
2	3	10.7%
3	3	10.7%
4	1	3.6%
5	0	0.0%
6	0	0.0%
7	0	0.0%
8	1	3.6%
9	0	0.0%
10 - extremely	3	10.7%

Exploratory Questions

Table 13: Question 13

Response	**N (28)**	**Percent**
0 – not at all	3	10.7%
1	2	7.1%
2	3	10.7%
3	1	3.6%
4	4	14.3%
5	3	10.7%
6	1	3.6%
7	3	10.7%
8	5	17.9%
9	0	0.0%
10 - extremely	3	10.7%

Table 14: Question 14

Response	N (24)	Percent
0 – not at all	12	50.0%
1	1	4.2%
2	2	8.3%
3	2	8.3%
4	0	0.0%
5	1	4.2%
6	0	0.0%
7	0	0.0%
8	2	8.3%
9	1	4.2%
10 - extremely	3	12.5%

Table 15: Question 15

Response	**N (27)**	**Percent**
0 – not at all	6	22.2%
1	2	7.4%
2	2	7.4%
3	1	3.7%
4	3	11.1%
5	2	7.4%
6	1	3.7%
7	4	14.8%
8	0	0.0%
9	1	3.7%
10 - extremely	5	18.5%

Table 16: Question 16

Response	**N (25)**	**Percent**
0 – not at all	10	40.0%
1	7	28%
2	1	4.0%
3	0	0.0%
4	1	4.0%
5	0	0.0%
6	0	0.0%
7	3	12.0%
8	1	4.0%
9	0	0.0%
10 - extremely	2	8.0%

Table 17: Question 17

Response	**N (26)**	**Percent**
0 – not at all	4	15.4%
1	5	19.2%
2	2	7.7%
3	0	0.0%
4	3	11.5%
5	4	15.4%
6	2	7.7%
7	2	7.7%
8	1	3.8%
9	0	0.0%
10 - extremely	2	7.7%

Table 18: Question 18

Response	N (27)	Percent
0 – not at all	5	18.5%
1	6	22.2%
2	1	3.7%
3	1	3.7%
4	4	14.8%
5	2	7.4%
6	3	11.1%
7	1	3.7%
8	1	3.7%
9	0	0.0%
10 - extremely	2	7.4%

APPENDIX E

Frequency Tables

Table 19: Emotion Average Frequency

Emotion Average

Valid	Frequency	Percent	Valid Percent	Cumulative Percent
3.00	1	3.0	3.0	3.0
3.60	2	6.1	6.1	9.1
4.00	1	3.0	3.0	12.1
4.40	2	6.1	6.1	18.2
4.60	1	3.0	3.0	21.2
4.80	2	6.1	6.1	27.3
5.00	3	9.1	9.1	36.4
5.40	2	6.1	6.1	42.4
5.50	2	6.1	6.1	48.5
5.60	1	3.0	3.0	51.5
5.80	2	6.1	6.1	57.6
6.00	2	6.1	6.1	63.6
6.25	1	3.0	3.0	66.7
6.40	2	6.1	6.1	72.7
6.67	1	3.0	3.0	75.8
6.80	1	3.0	3.0	78.8
7.00	1	3.0	3.0	81.8
7.20	3	9.1	9.1	90.9
8.00	1	3.0	3.0	93.9
8.60	1	3.0	3.0	97.0
10.00	1	3.0	3.0	100.0
Total	**33**	**100.0**	**100.0**	

Table 20: Risk Average Frequency

Risk Average

Valid		Frequency	Percent	Valid Percent	Cumulative Percent
	.00	2	6.1	6.5	6.5
	.50	2	6.1	6.5	12.9
	1.00	5	15.2	16.1	29.0
	1.50	1	3.0	3.2	32.3
	2.00	2	6.1	6.5	38.7
	3.00	2	6.1	6.5	45.2
	3.50	2	6.1	6.5	51.6
	4.00	5	15.2	16.1	67.7
	4.50	3	9.1	9.7	77.4
	5.00	2	6.1	6.5	83.9
	6.00	2	6.1	6.5	90.3
	6.50	1	3.0	3.2	93.5
	9.00	1	3.0	3.2	96.8
	9.50	1	3.0	3.2	100.0
	Total	**31**	**93.9**	**100.0**	
Missing	**System**	**2**	**6.1**		
Total		**33**	**100.0**		

Table 21: Confidence Average Frequency

Confidence Average

Valid	Frequency	Percent	Valid Percent	Cumulative Percent
.60	1	3.0	3.0	3.0
3.80	1	3.0	3.0	6.1
4.00	1	3.0	3.0	9.1
4.20	2	6.1	6.1	15.2
4.80	1	3.0	3.0	18.2
5.40	1	3.0	3.0	21.2
5.80	1	3.0	3.0	24.2
6.00	1	3.0	3.0	27.3
6.20	2	6.1	6.1	33.3
6.40	1	3.0	3.0	36.4
6.60	2	6.1	6.1	42.4
6.80	1	3.0	3.0	45.5
7.00	1	3.0	3.0	48.5
7.20	1	3.0	3.0	51.5
7.40	1	3.0	3.0	54.5
7.80	2	6.1	6.1	60.6
8.20	1	3.0	3.0	63.6
8.80	2	6.1	6.1	69.7
9.00	1	3.0	3.0	72.7
9.20	1	3.0	3.0	75.8
9.40	2	6.1	6.1	81.8
9.60	1	3.0	3.0	84.8
10.00	5	15.2	15.2	100.0
Total	**33**	**100.0**	**100.0**	

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