Analysis of Past Concussions and Current Health Measures: Long term impacts of Concussion on Cognitive, Emotion and General Health Scores in a Cohort of Adults 40-65

By

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Abstract

Not only is there a higher prevalence of concussion in junior, amateur and professional sport, but societal knowledge about concussion is greater than ever before. Current concussion research looks to prevent, manage and treat concussions. Little research has been done on the long-term impacts of previous concussions on adults relative to quality of life, cognitive decline, current health status or psychological well-being. Based on previous research on impacts of concussion it is anticipated that there will be a relationship between older adults with a history of concussion and scores on measures of cognitive functioning. As such the purpose of the present study was to predict cognitive failures using The Cognitive Failure Questionnaire (CFQ) in a sample of individuals drawn from the general population to determine the influence of concussion history, self-reports of measures of perceived health and quality of life and sex. Data were collected using a web-based survey in the general population of individuals, aged 40-65 years. Five surveys were presented to the general population with varying response rates that ranged from 108 to 130 respondents, respective of each survey. The results indicated that scores on the Cognitive Failures Questionnaire were predicted differently by reporting characteristics on the Short Form Health Survey 36 (RAND SF 36) and the Patient Health Questionnaire (PHQ) for individuals that reported history of previously diagnosed concussion. The results indicated that scores on the Cognitive Failures Questionnaire were predicted differently by reporting characteristics on the RAND SF 36 and the PHQ for individuals that reported history of previously diagnosed concussion. These results are intriguing in that they suggest that while not necessarily causal, there appears to be a relationship between concussion history and reporting on quality of life and perceived health surveys.

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Statement of Originality

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List of Abbreviations

AD- Alzheimer's disease

AL- Activation loss

BP- Bodily pain

CBC- Canadian Broadcasting Corporation

CFQ- Cognitive failure questionnaire

CHQ- Concussion history questionnaire

CTE- Chronic traumatic encephalopathy

CG- Concussion group

FT- Faulty triggering

FTT- Failure to trigger

GH- General health

HRQOL- Health related quality of life

LOC- Loss of consciousness

MAQ- Modifiable activity questionnaire

MCQ- Metacognitive questionnaire

MH- Mental health

MTBI- Mild traumatic brain injury

NCAA- National Collegiate Athletic Association

PA- Physical activity

PCS- Post concussion symptoms/syndrome

PF- Physical functioning

PHQ- Patient health questionnaire

PHQ SADS- Patient health questionnaire somatic anxiety depression symptoms

QOL- Quality of life

RAND- Research and development

RE- Role emotional

RP- Role physical

SAS- Statistical analysis system

SES- socioeconomic status

SF- social functioning

SF 36- Short form 36

TBI- Traumatic brain injury

UA- Unintended activation

VT- Vitality

Introduction

Current research on concussion injuries in sport is in a state of flux. While some researchers suggest that tests of memory, balance assessments, and reaction time are sufficient to ensure an accurate diagnosis and estimation of recovery, others suggest that more invasive techniques, which include blood analysis and functional magnetic resonance imaging, are necessary to recognize damage and subsequent recovery. The topic of head injuries (mild traumatic and traumatic brain injuries) and their association with long term health decline is central to many discussions in sport medicine. Not only do athletes have an interest in the injury and subsequent recovery path, but often individuals who may have experienced head trauma through recreational activities or employment duties express interest in understanding the consequences of the injury and how it may have/had an effect on their development - especially as they age. The predominant concern among the general population within those who may have experienced head trauma as a younger person is that they want to ensure no long term effects from previous injury, and that the injury will not result in a faster decline of health. The approaches to studying this topic have been observed in several populations of athletes, as well as individuals classified as previous athletes, and have reported a history of concussion. Current research continues to investigate ways of assessing, treating and preventing concussions (Martinez, 2011).

Concussion is one of the most difficult injuries to detect and diagnose, with a large number of unreported and undiagnosed injuries (Buck, 2011). The symptoms range in severity and frequency, and are subjective and experienced differently. More recently, as research into concussion injuries has expanded, there has been an increase in awareness of symptoms, and the ability of those injured to report related symptoms (Ruhe, 2014). The target population in the present study was selected to aid in the evaluation of the following research question: Do differences in measures of cognitive failures and perceived state of health exist between a cohort of previously concussed individuals versus a cohort of non-concussed individuals?

While higher concussion incidence rates occur between the ages of 15-35, the present study is concerned with the health status and concussion history of adults in the pre-elderly cohort, aged 40-65 years. Specifically, the present study intends to measure the relationships between concussion history and current health status, as well as perceived cognitive functioning in an aging cohort while recognizing the influence of random variability. The purpose of this research is to identify differences between cohorts who reported being concussed, compared to those who reported never being concussed, on standardized measures of health status and measures of cognitive reporting. The ability to identify differences between the concussed and non-concussed cohorts may contribute to research into potential long-term impacts of concussions and their influence on declines in health that exceed those normally attributed to aging.

Literature Review

1) Concussion

Concussions may impact health outcomes, or the way people experience and feel about their health. It is suggested that individuals with a history of concussion may demonstrate tendencies of lower scores of cognitive function and may also report poor health. The present study intends to measure the relationship between concussion history and current health status as well as perceived cognitive functioning in an aging cohort while recognizing the influence of random variability. The purpose of this research is to identify differences between cohorts who have reported past concussions, compared to those who have reported never having experienced a concussion, on standardized measures of health status and measures of cognitive reporting. Considering the debilitating impacts of concussion; including psychological, physical and physiological the concern is the level of health that exists in later years of those injured (Abrahams, 2014). Through identifying the presence of concussion history in the general population and evaluating any possible impact on one's health status, this project works to further identify and understand the presence of cognitive complaints and quality of life present in those injured.

Epidemiology

A general review of the literature indicates that the prevalence of concussion as a reported injury is rising in both professional and amateur sports, as well as in recreational pursuits. The overall prevalence of concussion in sport ranges from 0.1 to 21.5 per 1000 athlete exposures (Clay, 2013), this could be due to more reporting of symptoms or general knowledge and awareness of concussion symptoms. Although concussion injuries are most often associated with sport and recreational events, concussions are also observed in military combat, motor vehicle collisions, fights or assault, and falls. The highest incidence of concussion is observed in football and hockey players and the lowest incidence rates are observed in swimmers (Clay, 2013). The prevalence of concussion injuries is higher in games versus practices, with the incidence rate being six times higher during game time. The cause of a concussion is most likely to occur from contact with another player (50.8% of injuries) (Collins et al 2008). Injury reports indicate that 89% of concussions were a first occurrence, with 10.5% of concussion injuries being at least a second occurrence.

Interestingly, comparisons of concussion rates in general (not specific to sport), between males and females tend to show that females sustain more concussions than males. In a review of literature by King (2014) it indicated that some studies show the number of concussions sustained by females was double that of concussions sustained by males. Studies that reported females having more concussions than males also report females having a greater number of and severity of concussion symptoms, and they tend to require longer periods of time to recover from the concussion injury. This may not be directly indicative of incidence rate and may be indirectly related to gender and tendency for injured males to report less compared to females, although this is difficult to validate and not conclusive (King 2014).

There are many variations for the definition of concussion within the injury research literature. The definition of concussion has changed over time and terms like 'bell rung' and 'dinged' are no longer used to refer to concussion, as these labels were considered to minimize the importance of the injury (King, 2014). There is currently no universal definition agreed upon for the injury of concussion. The International consensus 2008 referred to a concussion as: a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces (Clay, 2013).

Traditionally loss of consciousness (LOC) was used as the gold standard symptom representative of a concussion, but this has changed since loss of consciousness is known to occur in 8-9% of concussion events. Although LOC remains a symptom, the current evidence of concussion risk reports that there is a six times likelihood of sustaining a subsequent concussion for those who experienced a concussion with the presence of LOC, compared to those who have no LOC in the presence of concussion (King, 2014).

The most common identifiers of concussion are amnesia and confusion, with headaches being the most common symptoms among concussed (Guskiewicz, 2003). Guskiewicz and colleagues (2003) used the definition of concussion as an injury resulting from a blow to the head causing an alteration in mental status and 1 or more of the following symptoms following injury: headache, nausea, vomiting, dizziness/balance problems, fatigue, difficulty sleeping, drowsiness, sensitivity to noise or light, blurred vision, memory difficulty and difficulty concentrating. The onset of symptoms may be immediate or delayed, although most concussions show symptoms within 24-72 hours post injury.

Concussion is defined as a head injury, and the term concussion is used interchangeably with mild traumatic brain injury (mTBIs). The variability of this injury is the reason why more research is crucial. Identifying predictors of, implications of and treatment for concussion is relevant to help each person who is impacted (Martinez, 2011).

Concussion is sometimes referred to as the ‘invisible injury’ because unlike other physical injuries, usually easily diagnosed and adapted standard protocol of recovery; concussions are less obvious to the medical professional for diagnosis. Concussions are understood and experienced differently, this impacts how individuals describe symptoms and understand their injury. Most statistics underestimate the incidence of concussion because most affected do not see a medical professional, especially in cases where a concussion is not accompanied by loss of consciousness (81-92%) (Daneshvar, 2011). Some symptoms may fail to show up in a patient or may go under reported for a long period of time, resulting in longer-term impacts from concussion seen in 20% of patients (Martinez, 2011).

Robbins (2014) demonstrated the difference in reporting and defining concussion; 15-50% of people with mTBIs report persisting symptoms, taking into consideration how concussion and symptoms can be assessed and may be defined differently for everyone. Concussion research is not clear in its direct attempt to identify the injury. Based on subjective experiences, or conflicting representations of the injury it is difficult to understand. Self reported history of concussion is sometimes the only tool available in assessing lifetime exposure to concussive brain trauma. The validity of self reported measure is accurate when a definition for concussion is provided for participants. Robbins et al (2014) look at self-reported history of concussion and considered whether former and current athletes understand the current definition of concussion. It is unclear whether athletes, when reporting history of concussion, are referring to the same definition of concussion as researchers and clinicians. Participants were asked to report history of concussion before given an accepted definition of concussion and then again after. Relative to their baseline estimates, participants reported significantly more concussions after interviewers were read the following definition: 'a concussion has occurred anytime you have had a blow to the head that caused you to have symptoms for any amount of time. These include: blurred or double vision, seeing stars, sensitivity to light or noise, headache, dizziness or balance problems, nausea, vomiting, trouble sleeping, fatigue, confusion, difficulty remembering, difficulty concentrating, or loss of consciousness' (Robbins et al, p.101).

Optimum recovery time identified by the National Collegiate Athletic Association is valued as extremely varied per person and per injury. Psychological response to injury is also unpredictable. Return-to-play for current athletes is tempered by consideration of many factors, such as age, physiology, physical and mental condition, presence of post-concussive syndrome (PCS), and the severity and frequency of concussive events. *Consensus Statement on Concussion in Sport guidelines 2013* outlines return-to-play guidelines for concussions, although recommended modification of the guidelines is supported in the case of situations where an individual may experience increased symptoms, long duration of symptoms or previous concussion history (2013).

A patient's symptoms tend to resolve with 7-10 days in 80-90% of patients (King, 2014). Immediate symptoms of concussion are also seen to show (80%) recovery within two to four weeks of injury; although this is variable. Actual damage may not manifest immediately because the neurological, physical, physiological, behavioral, and cognitive functions are differentially affected. There are cases where behavioral, cognitive, and/or personality deficits are more disabling than residual physical deficits in persons suffering concussion, as well as repeated concussions (Martinez, 2011). The assessment of athletes showed levels of dysfunction in cognitive tests, attention/concentration tasks, verbal fluency, reaction time, working and verbal memory, and executive functioning following a concussion diagnoses (Moser et al 2007). Levels of disturbance in cognitive functioning tend to resolve, relative to neuropsychological tests, within 2-14 days through 30 days (Moser et al 2007).

Spira (2014) showed that a recent concussion or ever having had a concussion was associated with emotional distress. Once an athlete experiences a concussion they have an increased risk for a future concussion (Moser et al, 2007). Athletes with reported previous history of concussion are four to six times more likely to experience a second concussion even if the second event or impact to the head is mild in severity (Guskiewicz, 2003).

Multiple lifetime concussions were associated with greater emotional stress, increase in persistent post concussion symptoms and reduced neurocognitive function relative to reaction time, not including memory tests (Spira, 2014). There is a relationship between history of concussion and lower levels of quality of life, high levels of depression and stress on health measures (McLeod, 2010). There also exists a difference between scores on memory tests of participants with history of one or two concussion compared to those with a history of multiple concussions (Beaumont et al, 2007). In terms of the long lasting impacts of concussion, the literature seems to show mixed interpretations of whether a concussion significantly causes debilitating impacts on areas of cognitive, emotional, or physical health in an individual. Some research reports statistically significant effects while other research show no significant effects (Brooks, 2013).

2) Cognitive functioning

Cognitive functioning is defined as an intellectual process where one is aware, perceives and understands ideas, or information sent to them from internal or external stimuli. It is made up of attention, memory and perception, and reasoning and thinking. The use of and strength of these functions differs uniquely for everyone. Cognitive functioning can be determined by multiple factors and can be determined by genetics, age, gender, history of chronic or mental illness, or history of head injury (Medical Dictionary, 2009).

Aging and Cognition

Age related changes in cognition is not uniform and is not particular to one certain pattern with age or gender (Riddle, 2007). The most common age deficits in cognition are in the areas of memory and attention, although this is not exclusive to all and some may not experience deficits, while others may have more severe deficits with age (Gilsky, 2007). Aging tends to cause deficits in attentional tasks that may require dividing attention or switching of attention pertaining to different stimuli. Based on the varying degree of skills across ages, gender and individuals we would expect to see variances in tasks relative to attention. Some individuals may have strength to recognize auditory stimuli compared to visual stimuli, impacting their performance, and this is important to recognize when looking at literature for cognition (Staub, 2013).

With age there is a tendency for working memory, which is involved in direct manipulation of information in order to remember its contents, to be impaired, while short term memory, the remembering of information over a short period of time, shows no deficits (Riddle, 2007). Long-term memory includes 5 subtypes: episodic, semantic, autobiographical, procedural and implicit memory. Age impairments are primarily in regards to episodic memory defined as: *memory based on certain events that took place in a particular place at a particular time.* Impairments in this memory make it difficult to understand or encode events. When an episodic memory impairment is present the encoding process is less detailed; therefore, less identifiable by memory. Although age can impair memory, it tends to show stronger recall for past events compared to recent events, yet detail remains limited (Glisky, 2007).

Working memory capacity can be determined by the efficiency of inhibitory processes. With age certain processes become less able to function completely. As these memory functions become less operative they may fail to discriminate between relevant stimuli. As they may lack the ability to prevent irrelevant stimuli from entering and being processed in working memory, this could causing a disturbance in the function and capacity of working memory (Hasher & Zacks, 1988). Aging adults who lack fully functional working memory processes, may become more easily distracted, as a result of poor encoding, retrieval and understanding of relevant information (Ballesteros, 2013).

The *mindlessness theory* proposes that decreases in ability to sustain attention is attributed to lack of exogenously supported attention, caused by the continuous, non stimulating and monotonous nature of tasks, as well as the decrease in endogenous executive attention as tasks gets longer or more difficult for an adult (Staub, 2013). Certain actions that are carried out day-to day become routine and less stimulating for the memory system, they require little sustained attention, and become automatic to the individual. This *under load/mindfulness theory* differs from the *over load theory* as the cause of failures in sustained attention. The *overload theory* indicates that as the mind experiences mental fatigue, it then lacks resources to help recover from actions or events that are stimulating, and prevents from effective encoding and attention processing (Staub, 2013).

Processing speed is a predictor of age related cognitive decline (Ballesteros, 2013). Planning an action requires large amounts of cognitive processing and attention skills. Planning is considering an executive function that requires a high level of cognitive processing: including two actions: formulation of plan and execution of plan. This tends to be recognized as being impaired in aging individuals and tends to decline with age even in healthy older adults (Sanders, 2012). The ability to carry through and complete tasks is less efficient for aging adults and they are able to complete fewer tasks (Sanders, 2013).

Current research has used traditionally formatted tasks (TFT) to measure cognitive processes of elderly. These tasks measure vigilance, or sustained attention. Participants are asked to monitor stimuli (audio or visual) for varying time periods and their response to stimuli is measured and recorded. These studies are useful but tend to vary based on type of and length of stimuli, therefore making it difficult to compare and draw results for this area of study (Staub, 2013). Overall, elderly participants had a larger response time and a decline in the ability to correctly detect and respond to stimuli. Vigilance performance and accuracy were both significantly impacted by age and it seems that advancing age may impose an increase in the limitations that one can process information and at what capacity, impacting the ability to see use and process information on a day-to-day basis (Staub, 2013).

Researchers are continuing to find one's self-evaluation along with objective performance of cognitive abilities to be important. One's belief about their level of functioning should not be disregarded in comparison to the objective measures used to determine cognitive strength. It seems that as an adult ages they tend to worry more about; and therefore become more aware of, their cognitive limitations. Meccaci (2006) showed that elderly people who scored higher on measures of cognitive lapses agreed that they tend to monitor their cognitive activity, although this seemed to be independent of age. Elderly people surprisingly tended to report lower levels of cognitive lapses, posing an interesting question regarding self-evaluation of cognitive lapses. As elderly people age, grow more worrisome about their cognitive abilities, and predictably show more cognitive failures with age; they fail to report these cognitive lapses in self-evaluations (Meccaci, 2006).

The cognitive failure questionnaire (CFQ) showed positive correlations with scales on the metacognitive questionnaire (MCQ). Scores showing a higher frequency of self reported cognitive failures showed a positive correlation with three factors (Meccaci, 2006)

1) Negative beliefs about the uncontrollability of thoughts and corresponding danger about worry
2) Cognitive confidence
3) Negative beliefs about thoughts in general

CFQ showed a significant decrease with age. The importance of considering age in the factors of cognitive abilities is crucial to understanding and changes in the way one functions on a cognitive level, we must consider age otherwise a misdiagnosis. Miller (2009) demonstrated age-related decline relative to certain measures of verbal, thought and memory processes. The strongest decline was seen in the measures of speed of thought processes, with preservation (low decline) on attention and concentration subtests. As adults age their verbal abilities and intelligence remain stable, and this seems to last into advancing ages; while nonverbal reasoning ability shows a decline with age. Ribot's Law (1882) indicated that those abilities learned earliest in life hold on the longest in the later years and are more resistant to conditions that are known to impact the brain and its functions.

3) Background of SF 36, Patient Health Questionnaire, Cognitive Failure Questionnaire

SF-36 was developed from the Medical Outcomes Study or RAND Health Insurance Experiment. It is a short-form derived from a larger 149-item instrument. The SF-36 consists of 8 subscales (*PF= physical function, RP= role limitation due to physical health, BP= bodily pain, GH= general health, VT= vitality, SF= social function, RE= role limitation due to emotional health, MH= mental health*) and two component scales (*PCS= physical component summary, MCS= mental component summary*). SF-36 demonstrates reliability, validity and frequency of measurement across populations and health care settings. It is useful in monitoring population health, evaluating the impact of different diseases, and monitoring and evaluating treatment and intervention outcomes in health practice (Hopman, 2006). The SF-36 has been translated into many different languages and is used across a diverse cultural background. A change in one's score of a 5-10 increase/decrease are considered significant in measuring a change in quality of life (QoL), is considered clinically and socially meaningful.

Hopman demonstrated a mean score of health related quality of life (HRQOL) that tended to remain stable over a three-year study that investigated HRQOL in men and women aged 40-59 years. Declines were seen more in the physical than mental domains in this age group (Hopman, 2006). SF-36 demonstrates improvements with age in the domains of *role limitation due to emotional health* (RE) and *general health* (GH). RE improvements were demonstrated in both men and women as they aged, while GH showed improvements in only men (Hemingway, 1997).

As age increases SF-36 shows lower levels of QoL for all physically oriented domains. With the exception of subscale *vitality (VT)*, the mentally oriented domains (*social functioning, mental health and, particularly role limitation in emotional health*) showed small improvements with increasing age, while *VT* showed mean declines as age increased. Mean scores show a relatively positive change in *role limitation due to emotional health* and *mental health* for all age groups until the age of 75 where mean scores begin to decrease. Men seem to decline on the *mental health* scale but not until the age of 65 and similar decreases in the mean scores for both men and women in the component score *physical health (PH)*, beginning at age 65 (Hopman, 2006).

Normative data for SF-36 are demonstrated through measurements of population groups and across different age groups, sex, and employment and education backgrounds. Normative data shows prevalence for younger men to have greater declines in general *mental health*, *role limitation in emotional health, vitality, and social functioning* than older men. Similarly, in women there is a relation in *vitality and mental health* scores (Ware, 1994). Older participants show greater declines in *physical functioning* than younger participants, and this is consistent across most literature (Hopman, 2006). In both Canadian and US normative data on the SF-36, men score higher on all domains and summary scores (Hopman, 2000).

Finally, the SF-36 shows differences between age groups but depending on the study these findings need to demonstrate continued stability and consistency of measures over time. In a three-year study compared to a five-year study the same individuals who experienced improvements or declines in three years tended to demonstrate similar declines or improvements in the five-year study, showing us that over a long period of time we can potentially identify changes that are relatively large. In relation to the above literature the means of SF-36 show fairly stable results over time within populations, with standard deviations showing large deviations from the mean. This requires further investigation but should indicate that there is strong declines or improvements being missed at the individual level, due to the standard errors balancing each other out and showing small mean differences (Hopman, 2006).

The patient health questionnaire (PHQ-SADS) is a measure of symptoms pertaining to a patient's health. It includes four subscales that measure somatic, anxiety and depressive symptoms in individuals. The subscales are PHQ-15, GAD-7 (including panic questions) and PHQ-9. Physicians use this measure in management and treatment of patients and regard it as useful and efficient. PHQ SADS allowed 88-93% patients rate the interaction with the physician to be *somewhat or very comfortable*, while as high as 89-93% of patients rated the interaction as *very or somewhat helpful* in allowing their doctor to understand their feelings and aid in communicating symptoms (Kocalevent, 2013). PHQ-15 subscale measures somatic symptoms using fifteen questions. The general population indicates 9.3% of individuals experience somatization syndrome (Kocalevent, 2013). This is defined as a syndrome where a person has physical symptoms that are in more than one part of their body but are not caused by any physical cause that can be found (http://www.nlm.nih.gov/medlineplus/ency/article/000955.htm). Females tend to score higher than males for somatization syndrome. This syndrome is correlated with measures on the PHQ-SADS of anxiety and depression, with inter-correlations being highest with depression. The triad (SAD) of somatic, anxiety and depression, and the comorbidity of these symptoms are the reason why this scale is used and well established. Correlations also exist between the PHQ measures and the SF-36 *physical component* summary score. The *mental component* score of the SF-36 was strongly correlated with PHQ subscale: depression (Kocalevent, 2013).

Currently, anxiety is one of the most debilitating syndromes, but one that is less accepted and treated within the healthcare system. According to Lowe (2008) 41% of patients with anxiety disorders reported no current treatment (Lowe, 2008). The GAD-7 (Anxiety scale from PHQ) has good reliability, criterion, construct, factorial and procedural validity, and can also be used in detecting posttraumatic stress disorder, social anxiety disorder, and panic disorder.

The Cognitive Failure Questionnaire evaluates differences in individuals on error proneness in cognitive and routine motor activities that are evaluated as easy. It evaluates typical or everyday behaviour; low difficulty activities (Wilhelm, 2010). CFQ has been used to look at different subscales of measurements of distractibility, planned social interaction, physical clumsiness and attention and absent-mindedness. Although the CFQ evaluates levels of attention in tasks, if tends to show weak correlates with sustained attention measures (Wilhelm, 2010).

High CFQ scores are associated with more accidents, hospitalizations, left-handedness, and overall mishaps (Larson, 1997). Total CFQ scores are related to personality traits of neuroticism and obsessional tendency symptoms. CFQ scores show significant correlations with Beck Depression Inventory, and with patients treated for depression and anxiety disorders. CFQ also demonstrates a negative correlation with dysfunctional self consciousness, defined as an expression of inflexibility of self focused attention (Wilhelm, 2010).

4) Mental and Emotional health -- Concussion and Health outcomes

Caron et al (2013) conducted a qualitative study to 'understand the meanings and lived experiences of multiple concussions in professional hockey players'. Retired males discussed the physical and psychological symptoms they experienced as a result of their concussions and how the symptoms affected their professional careers, personal relationships, and quality of life. This provided a qualitative understanding of the debilitating impacts concussion can have on emotional, social, physical and psychological health.

Mainwaring et al (2012) said “Emotions are integral to healthy human functioning, serve many psychosocial roles, and they are intimately connected to motivation, which propels us toward survival needs (nourishment and procreation) and protects us from danger by initiating avoidance or withdrawal behaviours”. Generally, emotions involve multiple regulatory systems and come about through multifaceted responses to stimuli (external or internal) (Roberts, 2003; Scherer, 2000). The reason we participate in certain activities in life and our social environment can be seen as driven by our emotions. This research looks to see if concussion shows differences in this area for participants.

The emotional part of the injury and recovery process is something that comes with the part of musculoskeletal injury as well. The athlete can experience withdrawal from sport; mood disturbances can include shock, depression, anger, frustration, anxiety, boredom, reduced self-esteem, fear of re-injury, and uncertainty about the future are common after musculoskeletal injury in sport (Mainwaring et al, 2004) The severity and characteristics of the injury impact people differently. These emotional reactions to physical injuries tend to be alleviated as an athlete is rehabilitated and is able to return to play. This verifies the impacts that injuries cause, not only impacting someone physically but other areas of one’s health as well. The specific relationship identified between injury and emotion is broadly known as the interaction between physical injury and psychological reactions (Caron, 2013).

In an adolescent sample individuals in the concussion group reported lower scores on SF-36 Quality of life scale for *bodily pain, general health perceptions, vitality, and mental health* subscales, and SF-36 *mental health component score.* In concussed individuals tested 72 hours post concussion, there were elevated levels of depression and fatigue. In a group of 60 concussed individuals they examined cognitive and emotional symptoms to see if there was a relationship post concussion. There appears to be lower cognitive and emotional function between days 1-3, continuing through to days 10-21 (Mainwaring et al, 2004).

The nature and duration of the depressed mood coincides with the established transient diminished cognitive function associated with concussion (Mainwaring, 2012). The presence of symptoms prior to the injury may result in further deterioration after the concussion, and continue to cause debilitation later in life. This area of concussion research is less focused and less entertained as it can be difficult to interpret how someone feels compared to a physical test of health. Further research and investigation can help us further understand the emotional impacts of concussion, and more specifically over the long term.

5) Physical activity and health

Researchers have established support for the benefits of physical activity (PA) in the health of individuals of all ages. PA has the potential to contribute to positive mood, positive self-image and positive self-esteem, and prevent symptoms that accompany mental illness (Matsalla, 2012). Although maintaining physical health is important for maintaining overall positive health, 1/3 of the world's population (Stanton, 2014) and 2/3 of Canadian population (Humphrey, 2014) fails to meet the minimal requirements for proper exercise. The benefit of physical exercise on mental health is one of the reasons why physical activity is recommended to help individuals with a positive self-image, levels of stress and anxiety, and symptoms of depression. Mental illness contributes to 13% of total global burden of disease; opening an opportunity for physical exercise to benefit this level of burden globally (Stanton, 2014). In measurements of well being, depression and cognitive decline demonstrated in groups of low, moderate, and high physical activity and aerobic fitness, results showed the highest level of general well being in groups with highest levels of physical activity and fitness. Inactive groups showed a significantly higher level of depression scores compared to others (Stanton, 2014). A modest level of activity was sufficient enough to see improvements in cognitive levels, and physical activity, and is therefore seen as a possible protective mechanism against cognitive decline later in life. The understanding behind this result and the mechanism that implies this is not conclusive. Although it is demonstrated in research that looks at cognition in healthy populations compared to those who show cognitive impairments. Stanton (2014) discussed a study where these two groups were compared cognitive performance after aerobic and resistance training, improvements were seen in both groups. The mechanisms contributed to this were reductions in vascular risk factors, increase of cerebral blood and increase in neural growth factors (Stanton, 2014).

A 12-year study by Small (2012), provided supporting evidence for cognitive health being based on lifestyle choices from the following influences: cognitive, social and physical activities. Physical activity does not seem to correlate with semantic memory, nevertheless when we look at cognitive activities we see different results. Cognitive activities were a leading indicator of changes in semantic memory, while semantic memory was a leading indicator in levels of social activity participation. The relationship with physical activity is seen in the presence of cognitive decline that can lead to an individual's cognitive performance, limiting their interest or abilities to participate in physical or social activity; increasing the chance of decline or impairment (Small, 2012).

Mental health is one of the more recent types of illnesses that show physical activity as a treatment or used in a combination with other treatments. For example, physical activity has been used as an intervention or co-intervention in treatment of mental illnesses like depression, anxiety and schizophrenia (Stanton, 2014). Physical activity tends to decrease stress, anxiety and depression, while increasing mood. Individuals with low self esteem tended to show a change in self-esteem following participation in aerobic physical activity. Significant research shows that 25-60 minutes of physical activity can contribute to an increase in positive mood, and decrease in negative mood (Matsalla, 2012). Children participating in physical activity during childhood have a lower chance of developing depression as an adult, while physical inactivity is an independent risk factor for developing depression as a adult (Stanton, 2014).

Social determinants of physical activity are important in understanding levels of physical activity. Socioeconomic status (SES) is a contributor to how active individuals are. Lower levels of physical activity in areas with lower SES lead to lower levels of general and mental health. There are different explanations as to why individuals in lower SES tend to show lower levels of physical activity including factors of safety, affordability, and availability. Physical activity is positively associated with self rated health and mental health (Meyers, 2014).

6) Concussion and Cognitive functioning

Vincent (2014) discusses TBI (traumatic brain injury) as an injury caused by an external force (the head being struck by an object, the head striking an object, the brain experiencing acceleration/deceleration movement without external trauma to the head, a foreign body penetrating the brain, or forces generated from events such as a blast or explosion, for example in military), that causes trauma to the structure of the brain and/or physiological disruption of normal brain functioning. This injury indicates a tendency to show at least one of the following symptoms: any period of loss of or decreased level of consciousness; any loss of memory for events immediately before or after the injury; any alteration in mental state at the time of the injury (confusion, disorientation, slowed thinking, etc.); neurologic deficits (weakness, loss of balance, change in vision, praxis, paresis/plegia, sensory loss, aphasia, etc.) that may or may not be transient; or intracranial lesion (Vincent, 2014).

The majority of TBIs are minor, with 75% being classified as mild TBIs, term referred to as concussions. Concussion injuries are associated with distinct risk factors that can affect an individual's health. Severe TBIs were reported to have serious consequences for children and adults and impact an individual's personality and cognition (Daneshvar, 2011). Risk factors for TBI include age (specifically there are differences in prevalence estimates for young versus older individuals). Likewise, males are at a higher risk than females, as are individuals from low SES, minority groups, and those with a reported history of alcohol or substance abuse, and history of TBI. Although the majority of present research is based on TBIs that are moderate to severe, repeated mild injuries are to considered noted as a risk for negative consequences of the health in individuals that experience head trauma and should not be ignored (Vincent, 2014).

Post concussion syndrome (PCS) can impact children or adults who experiences mTBIs or TBI. Post concussion symptoms continue for different reasons in individuals, contributed to by biological, physiological, psychological and/or social factors. As symptoms resolve for the majority injured, some symptoms continue in others; dizziness and headaches lasting past the first couple weeks, and/or psychological symptoms of depression, sensitivity and irritability showing up to one month post-injury (Daneshvar, 2011). PCS prevalence is higher women, who show a higher report of symptoms and debilitating impairments.

Chronic traumatic encephalopathy (CTE) is defined as a progressive neurodegenerative tauopathy seen in athletes and individuals who experienced head injury. CTE was originally found in boxers in 1920's although the medical field did not know of this condition, those injured were known to have a 'peculiar condition'. Therefore CTE was originally defined as dementia pugilistic and seen in those who experienced multiple hits to the head. It wasn't until the early 2000's when Dr. Bennent Omalu investigated the unknown death of a former NFL Football player Mike Webster and became known for him and his colleagues' findings published in the journal Neurosurgery titled "Chronic Traumatic Encephalopathy in a National Football League Player."

Alzheimer's disease (AD) with age of onset being 65, happens later compared to CTE which is seen in 40 and 50 year old adults and is a slow deterioration of cognitive abilities and function. Some factors that contribute to development of CTE are repeated impact to head, age of injury, and time interval between injuries. CTE seems to be a slow prolonged deterioration that can manifest after exposure to concussion in the past. The time and speed of this disease can be attributed to a cumulative effect of multiple injuries (Daneshvar, 2011).

The risks for concussion are real although remote. The chances of players being severely impacted are low, but healthcare professionals, coaches and others involved in sports must understand the frequency of the injury within sports. Coaches and professionals involved in sports should be aware of factors that can improve the ability to recognize concussion and aid in lowering the risk of players being further impacted (Clay, 2013). Some people may avoid or reject research supporting long-term impacts of concussion, showing reluctance in recognizing the risk that concussion presents. Some will find ways to disprove results and findings supporting impacts of concussion, but regardless it is of no question the current need for further research into this area along with increased awareness for everyone involved (NZ rugby world, 2014).

Summary of the Review of Literature

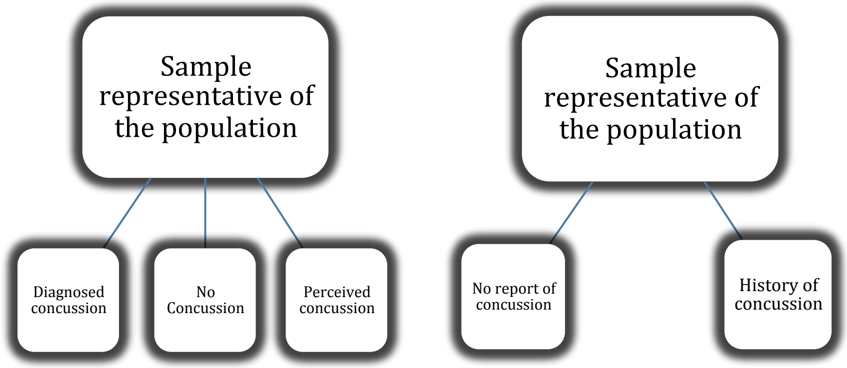
The purpose of presenting research in these areas is to gain a valuable understanding of predictors of health and to support the research purpose of determining underlying health conditions in adults impacted by concussions. More precisely, the indication of how these predictors are demonstrated in the selected sample, and if they may be a determinant of health outcomes. Establishing predictor variables that are related to health was one of the main determinants of the topics for literature review. Recognizing cognitive deficits with age is important to understand age declining aspects related to cognition in normal adults apart from the literature that on concussions and decline of cognition.

Method

Data in this study were collected using an online website, presented on a secure server at the University of Prince Edward Island. The front end was created with PHP and the data were stored in a mysql database. All data were analyzed using SAS: The Statistical Analysis System, version 9 (SAS Institute Inc.; Cary, NC). This website allowed participants to provide their information and complete all required surveys anonymously. The website was created at the University of Prince Edward Island and was approved by the Research Ethics Committee prior to recruitment of participants.

The research methodology was based on a retrospective cohort study design, which requires that participants self-report based on recall. In addition to reporting demographic information and responding to selected data collection tools; specifically, the Cognitive Failures Questionnaire, the RAND SF-36, and the Patient Health Questionnaire, participants also reported their history of concussion injury. As a result, the researcher was able to classify the respondents into a concussed versus a non-concussed group.

Classifying the participants according to concussion history enabled the researcher to examine the risk and/or protective characteristics of the various measures in relation to each self-report. The profiles for each participant were based on responses from the three health measures. The importance of assessing each component in this study was to examine differences in a group of concussed individuals versus non-concussed individuals. By separating the groups the researcher could begin to establish factors relative to the influences of previous concussion in individuals that may separate them from the general population.



The targeted sample was comprised of individuals between the ages of 40-65 years from the general population. Participants were not required to meet any other requirements to be included in the study. Information was collected on the participant's perceived or diagnosed health conditions as well as diagnoses of specific disorders that could be considered as important criteria in subsequent analyses. The classification of age group chosen was based around identifying individuals who do not have a high risk of age declining problems that we see in adults over the age of 65. Age 40 was used as the youngest age group.

A control group was not set *a priori*, however as participants identified their concussion history they were separated from the group of individuals that reported never having a concussion. Two groups were organized based on previous concussion (i.e. the exposed) vs. non-concussed (i.e. the non-exposed) individuals after reviewing the concussion history form.

Recruitment

The majority of participants were recruited via online contact and communication through social media using Facebook, Twitter, and University of Prince Edward Island Website. Participants could access the online surveys through the uniform resource locator (url) (http://health.ahs.upei.ca/WP/wordpress). Information on the research project was distributed through CBC-PEI through both a researcher interview and as part of the ongoing Public Service Announcements (PSA), and through the University Campus newspaper. Participants were also recruited through direct contact with professors and businesses that offered to forward the survey to fellow colleagues and employees. The online survey was available for participants beginning November 2014 and closed in February 2015.

Measures

The collection of datum was based on five measures of health and wellbeing. Before beginning a series of questionnaires, participants were asked to complete the following information regarding their background information: Name, date of birth, education, health status, indication of prior diagnosis of chronic illness and or mental illness, and identification of history of Alzheimer's in the family (see Table 1 below).

Statistical analysis

SAS: The Statistical Analysis System was used for all statistical analyses, to score the measures, as well as to separate variables into subscales consistent with methods described previously. The following data analyses plan was used to process all responses. Initially descriptive statistics were computed for all responses to identify measures of central tendency and frequency distributions, as well as to determine ranges of responses and compute 95% confidence intervals, where appropriate. Next, the Pearson Product Moment Correlation Coefficient procedure was used to evaluate the pairwise relationship between sum scores on the specific surveys (CFQ, SF-36 and PHQ) both within and between the concussed versus never concussed groups. Subsequent within scale correlations were also computed both within and between the concussed versus never concussed groups for the SF-36 (two component scores: *mental and physical health*, and *eight subscales*), the CFQ (sum score with *four subscales*) and the PHQ (*four subscales*). Independent group t-tests were computed to determine the extent of difference between the concussed versus never concussed groups on the sum-scores and subscale scores for each of the data collection tools. Finally, simple linear regression procedures using a backward elimination approach, where the parameter selection criteria was set to $p < 0.10$, were used to create statistical models that demonstrated the impact of the health measures (SF-36, PHQ) and associated subscales on the responses to the cognitive failures questionnaire.

Table 1. Descriptor of Measures: CHQ: concussion history questionnaire, SF36: survey Quality of Life, PHQ: Patient Health Questionnaire Somatic Anxiety Depression Scale, CFQ: cognitive failure questionnaire, MAQ: modifiable activity questionnaire

Scale	Measuring:	Questions	Scoring Range	Reliability and Validity
CHQ	Concussion history, total number of concussions, number of diagnosed concussions	4 items	Number of concussions (0-maximum number reported) Most recent: Year	Designed by researcher and supervisor
SF 36	Eight subscales: general health perception, energy, social functioning, physical functioning, emotional health, role physical, role emotional, and pain. Two component scores: mental health and physical health	36 items	0-100	(Hopman,2000)
PHQ-SADS	PHQ-15 Somatic symptoms, GAD-7 anxiety symptoms, PHQ-9 depression symptoms and Panic Scale: panic symptoms Health Perception: how difficult have these problems made it for you to do your work, take care of things at home, or get along with other people?	PHQ-15: 15 items GAD-7: 7 items PHQ-9: 9 items Panic scale: 5 items Health perception: 1 item	PHQ-15: 1-45 GAD-7: 1-28 PHQ-9: 1-36 Panic: 0-10 Health perception: 0-4 Cut-off points represent 10, 15, and 20 for mild, moderate and severe levels of somatic, depressive and anxiety symptoms.	PHQ-15 (Kroenke, 2002) (Kocaleven,2013) GAD-7 (Lowe,2008) PHQ-9 (Martin,2006)
CFQ	Cognitive failures Subscales: unintended versus intended action, slips versus lapses in memory and exogenously and endogenously cognitive failures	25 items, 5 point scale	1-125	(Knight,2004)

Results

Summary

As noted previously, the purpose of the present study was to determine cognitive failures using The Cognitive Failure Questionnaire (CFQ) in a sample of individuals drawn from the general population to determine the influence of concussion history, and self reported measures of perceived health and quality of life. The following chapter presents the results from the online data collection using five standardized instruments (SF-36, PHQ, CFQ, CHQ, and MAQ) and analyses.

Demographics

The final sample of participants consisted of 112 individuals (n_{males}= 42, $n_{females}$= 70), ranging in age between 40-65 years. The average age for males was 54 years of age (Mean=54.45, SD=7.11, Median=55) and for females was 51 years of age (Mean=51.34, SD=6.19, Median= 52). Background information indicated that 110 participants reported a perceived health level of excellent or good, while only two participants reported a perceived health of fair or low health. Background information regarding self-report of chronic disease or illness showed that 12 participants suffered from at least one chronic condition: defined as including any form of chronic illness, disease or symptom complex or disability, and is often of long duration and generally slow progression (World Health Organization, 2014). Four females (5.8%) reported diagnoses of chronic disease, while eight males (19%) indicated at least one prior diagnosis of chronic illness. Self-reports of diagnosed mental illness indicated that ten participants had at least one prior diagnosis of mental illness representing 9% of the total respondents. This finding was further subdivided by sex reflecting seven females (10% of the female cohort), and 3 males (7% of the male cohort) reported at least one prior diagnosis of mental illness. Finally, in describing previous history of illness, participants were asked to indicate whether there was a record of family history of Alzheimer's disease. The results showed that 28.8% (32/111) of respondents indicated a history of Alzheimer's disease in their family.

Descriptive Statistics

Descriptive statistics including mean ± standard deviation and 95% confidence intervals, where appropriate, were computed for each of the survey tools and the results are presented below.

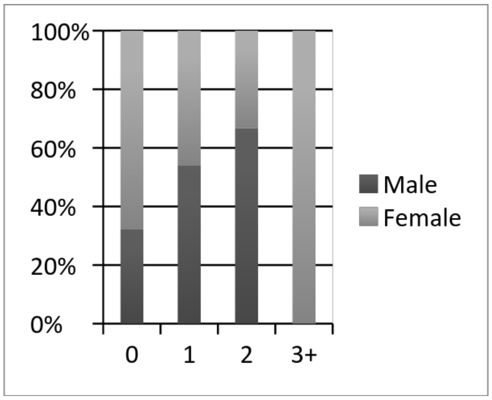
Concussion History Questionnaire (CHQ)

This questionnaire asked participants questions that allowed the freedom to demonstrate several different aspects of concussion history within this particular population.

The number of concussions reported was separated into two groups: i) concussed and ii) non-concussed, based on responses to the two survey questions:

- *How many concussions have you had?*
- *How many of your concussions were diagnosed by a healthcare professional?*

In the sample of 112 participants, slightly more than 64% of respondents indicated that they had never experienced a concussion. Of the 35% of respondents who indicated that they had perceived a concussion injury at some point in their lives, 15.7% reported having at least one concussion, while 7.14% reported at least 2 concussions, and 13.4% reported at least 3 or more concussions. Further, more than 73% percent of a sample of 82 respondents reported no history of being diagnosed with a concussion. However, of the respondents who were diagnosed with a concussion, 21.43% (n=24) reported a history of 1 diagnosed concussion, while 3 individuals reported 2 diagnosed concussions and 3 individuals reported 3 or more diagnosed concussions. In the following tables, pertaining to the reports of The Rand SF-36, The Cognitive Failures Questionnaire, and the Patient Health Questionnaire, the data were first reported for the total group of respondents, and then subsequently re-organized first by age groups (40-49, 50-59, and 60-65) and then according to concussion history -- i.e. perceived and diagnosed concussions. Follow-up statistical analyses were used to evaluate the comparisons of average measures across age groups, and across grouping strategies based on reported concussion history. The concussed versus non-concussed groups were important to distinguishing characteristics that may be related to the frequency of reports of concussions and the relationship with measures of health outcomes across the sample.



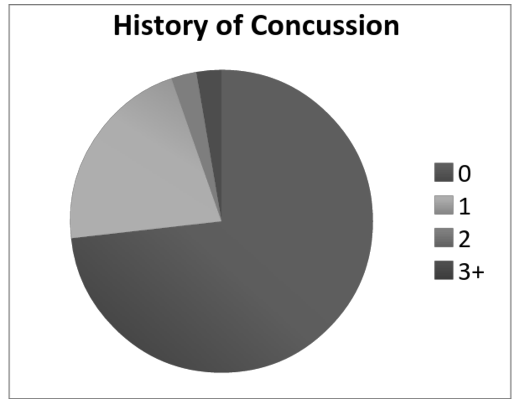


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Figure 1: Number of concussions by Sex

Figure 2: History of Concussion by percent

The Rand Short Form 36 Health Survey

Descriptive statistics for the Rand Short Form 36 Health Survey are presented in Table 2 below. The survey is separated into eight subscales which cover the following areas: *i) general health, ii) physical functioning, iii) role limitations_in physical health, iv) role limitations in emotional health, v) pain, vi) social functioning, vii) mental health and viii) emotional health*. In addition, two sub-component scores*: i) mental health and ii) physical health* were also generated from the list of symptoms.

Table 2. Descriptive Statistics for The Rand Short Form 36 Health Survey

SF-36 Sub-scales	mean ± sd	minimum score	maximum score	standard error	95% confidence interval
general health (n=108)	71.71 ± 18.51	10	100	1.78	= 71.71 ± 3.49
physical functioning (n=108)	88.43 ± 16.43	0	100	1.58	= 88.43 ± 3.49
role limitations (due to physical health) (n=108)	86.81 ± 29.10	0	100	2.80	= 86.81 ± 5.49
role limitations due to emotional health (n=108)	88.27 ± 27.46	0	100	2.64	= 88.27 ± 5.17
pain (n=108)	81.48 ± 17.16	20	100	1.65	= 81.48 ± 3.23
social functioning (n=108)	58.3 ± 20.44	0	100	1.96	= 58.3 ± 3.86
energy/vitality (n=108)	66.2 ± 19.3	5	95	1.86	= 66.2 ± 3.65
mental health (n=108)	78.85 ± 16.16	12	100	1.55	= 78.85 ± 3.04

Table 3. Descriptive Statistics for sub-component scores of The Rand Short Form 36 Health Survey

SF-36 Sub-component Scores	mean ± s	minimum score	maximum score	standard error	95% confidence interval
mental health(*) (n=108)	72.92 ± 14.68	6.75	94	1.41	=72.92 ± 2.76
physical health (*) (n=108)	82.11 ± 17.20	10.63	100	1.66	= 82.11 ± 3.25

(*) denotes variables derived from SF-36 sub-component scales

The results of the RAND SF-36 indicate that the total group of respondents self-reported to be of generally good health both physically and mentally. These two scores are generally accepted as measures of an individual's perceived quality of life related to health (mental and physical). The scores indicate that the respondent's perceived state of physical health is significantly higher than their perceived state of mental health, in the total group, as determined by the 95% confidence intervals for the two mean scores. This difference exists despite the higher standard deviation in the perceived *physical health* scores in comparison to the scores for the perceived state of *mental health*. The means and standard deviations show how each cohort of individuals show large variance between scores within the entire group. The purpose of demonstrating these means is to fully understand the sample cohort and the health scores as reported.

Descriptive statistics were also computed for the SF-36 component scores for ages ranging from 40-65. Age was not reported for all respondents, therefore the sample size dropped from 112 to 103. Ages were grouped as noted earlier and the means ± standard deviations for the subscale scores are presented in Table 4.

Table 4. Comparison of The Rand SF-36 Physical Health and Mental Health Subscale Scores by Age Group

The Rand SF-36 Component Score	Age-group 1: 40-49 (n= 31) mean ± s	Age-group 2: 50-59 (n=55) mean ± s	Age-group 3: 60-65 (n= 17) mean ± s
Mental Health	71.12 ± 16.56	75.32 ± 10.4	71.20 ± 19.04
Physical Health	77.36 ± 18.66	85.76 ± 12.26	81.29 ± 22.20

The comparison of The Rand SF-36 component scores for *physical and mental health* by age group suggest that the youngest age group (40-49) scored, on average, lower than the other two older age groups. However, a follow-up one way ANOVA for The Rand SF-36 component scores for *physical and mental health* by age group did not support a significant difference -- *Mental Health* = (F= 1.12; df=2,100; p=0.33), *Physical Health* = (F= 2.72; df=2,100; p=0.07).

The next step in analysis considered the total group of respondents separated according to reported concussion history. Following several t-test comparisons across the various scores SF-36, CFQ, PHQ and the related sum scores and subscales scores, between the group reporting diagnosed concussion and the group reporting a perceived concussion wherein no significant differences were observed, the researcher decided to stratify the groups as follows: individuals that explicitly reported never having a concussion were placed in group 1, while the complementary group consisted of individuals that reported at least one concussion. It is important to note that individuals in the latter group may have reported that they experienced a concussion but never sought medical diagnosis. Therefore, participants reporting at least one concussion regardless of whether or not it was perceived or diagnosed were included in group 2. After separating the responses into two groups based on history of concussions, the following outcomes were found between the two groups.

Table 5: The RAND SF 36 subscales for Concussion and Non-concussion grouping

SF-36 Sub-scales	Never Concussed mean ± s (n =76)	At least 1 reported concussion mean ± s (n= 32)	t test values* (p)
general health	14.07±2.27	14.43±2.65	t = -0.67 (0.51)
physical functioning	28.29±2.27	26.25±4.94	t = 2.24 (0.03)*
role limitations (physical health)	7.72±0.76	6.78±1.60	t = 3.18 (0.003)*
role limitations (emotional health)	5.68±0.80	5.34±1.04	t = 1.66 (0.10)
pain	10.21±1.37	8.87±1.70	t = 3.95 (0.0002)*
social functioning	10.12±1.61	9.34±2.25	t = 1.77 (0.08)
energy/vitality	15.01±1.47	15.16±2.02	t=-0.36 (0.72)
emotional health	22.17±2.19	20.78±3.12	t=2.30 (0.03)*

Table 6: Comparison of The RAND SF 36 component scores for Concussion and Non-Concussion groups

The Rand SF-36 Component Score	Never Concussed mean ± s	At least one concussion mean ± s (n= 30)	T test values* (p)
Mental Health	52.99±4.05	50.63±5.66	t=2.14 (0.04)*
Physical Health	60.30±3.31	56.33±6.17	t=3.43 (0.001)*

Table 5 and 6 represents comparisons between the mean scores on the SF-36 scales between the concussed and non-concussed group, where the concussed group reported at least one concussion regardless of whether or not it was perceived or diagnosed. The differences presented in Tables 5 and 6 demonstrate how concussion can separate the two cohorts on measures of health. Significant differences support the idea that concussion groups differ in areas that need to be further explored and although the cause of the difference is unknown, this present study demonstrates the presence of differences, not the cause of these differences between groups. The following differences between means were statistically significant between concussed versus non-concussed groups*: physical functioning (p= 0.03), role limitations due to physical health (p= 0.003), pain (p= 0.0002), and emotional health (p=0.03).* Furthermore, the concussion group was significantly lower on both component scores *mental health (p= 0.04) and physical health (p= 0.001).* In addition, differences between the groups on *role limitation due to emotional health and social functioning* approached significance (p= 0.10 and p= 0.08 respectively).

Cognitive Failure Questionnaire (CFQ)

After examining the differences between mean scores on The RAND SF 36, the next step was to determine if the concussion groups differed on the Cognitive Failure Questionnaire (i.e., on measures of attention, memory and reporting of cognitive failures). The descriptive statistics for the Cognitive Failure Questionnaire are presented in Table 6. The following results used a sum score from the 25 items of the CFQ where each item had a response range from 1 to 5. The sum score was then sub-divided into four sub scales labeled as follows*: i) activation loss, ii) faulty triggering, iii) failure to trigger, and iv) unintended activation.*

Table 7. Descriptive Statistics for the Cognitive Failures Questionnaire

CFQ Categories	mean ± s	minimum score	maximum score	standard error	95% confidence interval
CFQ Sum Score (n=112)	51.24 ± 15.58	25	125	1.47	=51.24 ± 2.88
CFQ Activation Loss (n=112)	17.57 ± 4.80	7	35	0.45	= 17.57 ± 0.88
CFQ Faulty Triggering (n=112)	6.56 ± 2.61	4	20	0.24	= 6.56 ± 0.47
CFQ Failure to Trigger (n=112)	20.23 ± 6.99	11	55	0.66	= 20.23 ± 1.29
CFQ Unintended Activation (n=112)	6.88 ± 2.55	3	15	0.24	= 6.88 ± 0.47

These results show that the total group average for the sum of the Cognitive Failures Questionnaire score (± the standard deviation) was near the midpoint of the possible scoring range (25 to 125) for this assessment tool. This finding was higher than means of Sum CFQ scores reported in previous literature (M=42.49, SD=12.34) (Payne & Schnapp, 2014), (M=32.7, SD=11.2) (Pfeifer, Os, Hanssen, Delespaul, & Krabbendam, 2008). Given the sample size of 112 individuals and a low standard error, the bandwidth of the 95% confidence interval is also small and suggests that the true population mean is between a low score of 48 and upper score of 54, relative to the age population 40-65. The mean scores are close to the proximity of the scale midpoint and indicate a moderate number of cognitive failures.

Ballesteros (2013) indicates certain qualities of cognitive functioning are impacted in normal aging. Determining normal aging declines of cognitive functioning is important for this proposed study. Although the CFQ is not directly measuring cognitive functioning, it highlights the presence of tendencies toward slips in action and memory, and how an individual perceives their level of cognitive abilities.

Table 8. Comparison of Total CFQ Score by Age Group

Age-group 1: 40-49 (n= 29) mean ± s	Age-group 2: 50-59 (n=54) mean ± s	Age-group 3: 60-65 (n= 17) mean ± s
51.62 ± 15.11	54.74 ± 17.02	54.00 ± 16.69

The comparison of CFQ scores by age group reported in Table 8 above, indicate that the youngest age group (40-49) scored on average lower than the other two older age groups. However a follow-up one-way ANOVA for Total CFQ scores by age group did not support a significant difference ($F=0.34$; $df=2,97$; $p=0.71$) suggesting age was not a confounding variable that seems to impact this cohort of respondents in cognitive failures.

Table 9. Comparison of Cognitive failure questionnaire between Non-Concussed and Concussed groups

CFQ Categories	Non-Concussed mean ± s (n = 65)	Concussed mean ± s (n=36)	t test* (p)
CFQ Sum Score	48.35 ± 14.08	53.94 ± 15.04	t = -1.83 (0.07)
CFQ Activation Loss	16.69 ± 4.54	18.61 ± 4.89	t = -1.94 (0.05)*
CFQ Faulty Triggering	6.09 ± 2.32	6.83 ± 2.55	t= -1.45 (0.15)
CFQ Failure to Trigger	19.15 ± 6.25	21.14 ± 6.59	t=-1.48 (0.14)
CFQ Unintended Activation	6.41 ± 2.18	7.36 ± 2.65	t=-1.83 (0.07)

There was an increase in reported cognitive failures for Sum of CFQ scores and all subscales of the CFQ for the concussed group, and although all but one did not show to be statistically significant based on the t-test two-group comparison and an alpha level of 0.05, the relationship demonstrates differences between these two groups. Concussed groups reported a higher number of cognitive failures in the concussed group compared to the non-concussed group. This comparison was significant in subscale CFQ- *Activation Loss* at $p<0.05$. The comparison within Sum of CFQ and CFQ-*Unintended Activation* should not be ignored and shows a difference between the two groups with $p<0.07$(although not significant). It is apparent there were small differences across the concussed and non-concussed groups. The data presented above support the grouping of no concussion and any history of concussion, aiding in the ability to distinguish differences between health measures and demonstrating significant differences between concussions groups on SF-36 and CFQ.

Patient Health Questionnaire (PHQ)

The descriptive statistics for the Patient Health Questionnaire (PHQ) are presented in Table 10. The survey is based on four subscales, with an additional single question based on an individual's health perception. Consistent with the statistical analyses for all surveys, the scores on the Patient Health Questionnaire were first analyzed for all participants as a total group (Table 10), and then based on reports of concussion history -- i.e. perceived concussion (Table 11) and diagnosed concussion (Table 12) reporting groups.

Table 10. Descriptive Statistics for The Patient Health Questionnaire Responses in Total Group

Categories	mean ± s	minimum score	maximum score	standard error	95% confidence interval
PHQ-15 (somatic symptoms) (n=117)	28.06 ± 4.33	1	45	0.40	= 28.06 ± 0.78
GAD-7 (anxiety symptoms) (n=117)	9.58 ± 4.02	1	28	0.37	= 9.58 ± 0.73
PHQ-9 (depression symptoms) (n=117)	11.61 ± 4.57	1	36	0.42	= 11.61 ± 0.83
Panic Scale (n=117)	3.93 ± 3.04	1	12	0.28	= 3.93 ± 0.55
Self assessed health status (n=117)	1.18 ± 0.71	1	4	0.07	= 1.18 ± 0.13

The results for the total group reports on the PHQ indicate that mean scores for somatic, anxiety, depression, and panic exist in this population. Somatic symptoms are at the higher end of the scale and could be classified as a severe level of somatic symptoms in this sample.

Anxiety and depression symptoms are low and indicate a mild level of anxiety and depressive symptoms in the sample. The results for the patient health questionnaire compared across the two groups showed that there were no significant differences on any of the subscales in the PHQ. Although the concussed versus non-concussed groups were not significantly different on any of the Patient Health Questionnaire subscales: *somatic, anxiety, depression, or panic symptom*, *or self health perception question*. These subscales were used in subsequent regression models to predict cognitive failures using the CFQ responses.

Correlations between subscales in each survey

The importance of measuring correlations between variables and their subscales was to show estimates of predictors and to demonstrate within scale reliability: showing consistency for the intended health measure. With regards to the SF-36 scale, it is suggested that each subscale describes a respondent's quality of life in relation to the component subscales. Therefore, given that each subscale contributes to the overall construct it is essential that the relationship between subscales be measured.

SF-36 showed significant correlations between the *physical health component score* and its four subscales of *pain, physical functioning, general health perceptions and role limitation due to physical health*. Strong correlations were shown between *role limitations due to physical health, and role limitations due to emotional health* indicating a positive relationship with correlation coefficient $r=0.51$ $p<0.01$. *Role limitations due to emotional health* were strongly correlated with *emotional health* ($r=0.50$ $p<0.01$). Energy levels indicated some of the highest correlation coefficients with *emotional health* ($r=0.70$ $p<0.01$), *general health perceptions* ($r=0.52$ $p<0.01$), and *physical health* ($r=0.56$ $p<0.01$) and *mental health component scores* ($r=0.71$ $p<0.01$). *Emotional health* is a subscale part of the *mental health component score*, indicating a significant relationship ($r=0.66$ $p<0.01$). Within scale relationships aide the present study in isolating variables and subscales within a cohort of individuals.

CFQ (Cognitive failure questionnaire) showed significant correlations between all subscales, at an alpha level $p<0.05$ as did the PHQ except for the *panic scale* showing a weak positive relationship with *somatic, anxiety, depression and self health perception* subscales of the PHQ. Correlations identified between variables, which comprised the subscales on each of the surveys were important to note as these measures were used in subsequent backward elimination regression models intended to predict the respondent's cognitive failures scores. The results below show the relationships between the subscale measures of the predictor set that includes the SF-36 subscales, the PHQ subscales, and sex with the CFQ total score and its subcomponent scores, separated by concussion history.

Table 11: Correlations between CFQ scores and the subscales of SF-36, PHQ, and sex separated by concussion history (Non Concussed)

SF-36 Sub-scales	Sum CFQ	CFQ AL	CFQ FT	CFQ FTT	CFQ UA
Physical functioning	r=-0.14 p=0.24	r=-0.06 p=0.63	r=-0.16 p=0.19	r=-0.13 p=0.28	r= -0.22 p= 0.06
Pain	r=-0.09 p=0.46	r=0.004 p=0.97	r=-0.09 p=0.46	r=-0.08 p=0.52	r= -0.23 p= 0.05*
Vitality (energy)	r=-0.11 p=0.35	r= -0.29 p=0.01*	r=0.02 p=0.86	r=-0.06 p=0.56	r=-0.008 p=0.94
Mental Health	r= -0.23 p= 0.05*	r= -0.34 p=0.05*	r=-0.12 p=0.31	r= -0.20 p= 0.10	r=-0.12 p=0.31
Physical Health	r=-0.08 p=0.5	r= -0.21 p= 0.06	r=-0.003 p=0.98	r=-0.04 p=0.72	r=0.02 p=0.85

Table 12: Correlations between CFQ scores and the subscales of SF-36, PHQ, and sex separated by concussion history (Concussed)

SF-36 Sub-scales	Sum CFQ	CFQ AL	CFQ FT	CFQ FTT	CFQ UA
Physical functioning	r= 0.37 p= 0.05*	r= 0.50 p= 0.007*	r=0.29 p=0.14	r=0.30 p=0.13	r=0.25 p=0.19
Role limitations (due to physical health)	r= 0.43 p= 0.02*	r= 0.52 p= 0.004*	r=0.30 p=0.13	r= 0.36 p= 0.06	r= 0.37 p= 0.05*
Pain	r= 0.41 p= 0.03*	r= 0.56 p= 0.002*	r=-0.08 p= 0.7	r= 0.33 p= 0.09	r= 0.33 p= 0.09
Energy	r= -0.33 p= 0.09	r= -0.45 p= 0.01*	r= -0.20 p=0.31	r= -0.35 p= 0.07	r=-0.11 p=0.55
Mental Health	r= -0.38 p= 0.04*	r= -0.45 p= 0.02*	r=-0.27 p=0.16	r= -0.39 p= 0.04*	r=-.21 p=0.29
PHQ Somatic	r=0.28 p=0.15	r=0.18 p=0.36	r=0.22 p=0.27	r=0.30 p=0.12	r= 0.33 p= 0.08
PHQ Depression	r= 0.37 p= 0.05*	r=0.27 p=0.16	r=0.31 p=0.10	r= 0.37 p=0.05*	r= 0.42 p= 0.03*

The findings in this study demonstrate important relationships between responses on selected health measures. The between scale correlations demonstrate the relationship between health measures and those that are significant for concussed and non-concussed groups. Significant correlations reported in Tables 11 and 12 show important relationships between subscales variables that are subsequently included in the backward elimination regression equations.

In the present study, the Cognitive Failures Questionnaire was used as a dependent measure to evaluate the impact of the subscales of SF-36 and PHQ on cognitive failures using backward elimination regression procedures while controlling for history of concussion.

Regression Model 1. no reported concussions -- R-Squared = 0.90

Model Sum CFQ = 0.22 * (SF_{36}pain_estimates) +0.2 * (SF_{36}Role limit Emot Health) + 9.79 (sex)

Variable	Parameter Estimate	Standard Error	F Value	Pr > F
pain_estimates	0.22	0.10	4.42	0.04
role limitations due to emotional health	0.20	0.08	6.17	0.02
Sex	9.79	3.55	7.60	0.008

Regression Model 2. no reported concussions -- R-Squared = 0.92

Model CFQ-AL = 0.08(SF_{36}pain_estimates) + 0.06 (SF_{36}Role limit Emot Health) +3.13(Sex)

Variable	Parameter Estimate	Standard Error	F Value	Pr > F
pain_estimates	0.08306	0.03089	7.23	0.0091
role limitations due to emotional health	0.06304	0.02454	6.60	0.0125
sex	3.12849	1.06431	8.64	0.0045

Regression Model 3. no reported concussions -- R-Squared = 0.85

Model CFQ-FT=0.03(SF_{36}Role limit Physical Health) +0.03(SF_{36}Social Functioning)+1.41(Sex)

Variable	Parameter Estimate	Standard Error	F Value	Pr > F
role limitations (due to physical health)	0.03	0.01	8.81	0.004
Social Functioning	0.03	0.02	4.91	0.03
sex	1.40	0.58	5.86	0.02

Regression Model 4. no reported concussions -- R-Squared = 0.88

Model CFQ FTT=0.10(physical health) +0.09(SF_{36}Role limit Emot Health) + 0.08 (SF_{36}Social Functioning)

Variable	Parameter Estimate	Standard Error	F Value	Pr > F
physical Health	0.10	0.04	6.73	0.01
role limitations due to emotional health	0.08	0.03	7.15	0.009
Social Functioning	0.08	0.04	3.38	0.07

Regression Model 5. no reported concussions -- R-Squared = 0.87

Model CFQ-UA=0.03(SF_{36}physical health)+0.05(SF_{36}physical functioning)

Variable	Parameter Estimate	Standard Error	F Value	Pr > F
SF_{36}physical health	0.03	0.02	4.53	0.04
SF_{36}physical functioning	0.05	0.01	10.60	0.002

Predictors of No Concussion group

The predictors of SF-36 were included in the computed regression models 1-5 presented above for the non-concussion group. *Role limitations due to emotional health* seems to be a predictor of three scales of CFQ in the non-concussed group. *Physical health* is a predictor for two scales of the CFQ and is a strong variable in predicting the scores of CFQ. *Social functioning* is a variable that also predicts two of the scales of CFQ. These regression models demonstrate unique characteristics of the non-concussed group on health measures from SF-36 that predict outcomes of cognitive failures.

Regression Model 6. Diagnosed concussions -- R-Squared = 0.97

Model SumCFQ= -1.01 (SF_{36}general health) + 0.61(SF_{36}pain estimate) + 0.45(SF_{36}physical functioning) +13.78(sex) + 7.73(perceived concussion)

Variable	Parameter Estimate	Standard Error	F Value	Pr > F
SF_{36}general health	-1.01436	0.16561	37.51	<.0001
SF_{36}pain estimate	0.61491	0.18638	10.88	0.0034
SF_{36}physical functioning	0.44593	0.17336	6.62	0.0178
sex	13.78459	3.99853	11.88	0.0024
perceived concussion	7.72597	4.00806	3.72	0.0675

Regression Model 7. Diagnosed concussions -- R-Squared = 0.96

Model CFQ-AL= - 0.28(SF_{36}general health) + 0.13(SF_{36}pain estimate) + 0.23 (SF_{36}physical functioning) + 4.37(Sex)

Variable	Parameter Estimate	Standard Error	F Value	Pr > F

SF_{36}general health	-0.28186	0.06526	18.66	0.0003
SF_{36}pain estimate	0.12651	0.07224	3.07	0.0938
SF_{36}physical functioning	0.22887	0.06115	14.01	0.0011
sex	4.37159	1.38158	10.01	0.0045

Regression Model 8. Diagnosed concussions -- R-Squared = 0.94

Model CFQ-FT= -0.15 (SF_{36}general health) + 0.08 (SF_{36}pain estimate) + 0.07 (SF_{36}physical functioning) + 2.91(Sex)

Variable	Parameter Estimate	Standard Error	F Value	Pr > F
SF_{36}general health	-0.15087	0.02981	25.62	<.0001
SF_{36}pain estimate	0.08237	0.03300	6.23	0.0205
SF_{36}physical functioning	0.06718	0.02793	5.79	0.0250
sex	2.91413	0.63107	21.32	0.0001

Regression Model 9. Diagnosed concussions -- R-Squared = 0.98

Model CFQ-FTT= -0.15 (SF_{36}general health) + 0.40 (SF_{36}pain estimate) + 0.19 (SF_{36}physical health) - 0.14 (SF_{36}energy) - 0.13 (SF_{36}Role Limit Physical Health) + 0.10 (SF_{36}Role Limit Emotional Health) + 4.33 (Sex) + 3.87 (perceived concussion)

Variable	Parameter Estimate	Standard Error	F Value	Pr > F
SF_{36}general health	-0.39	0.07	32.76	<.01
SF_{36}pain estimate	0.39	0.07	27.55	<.01
SF_{36}physical health	0.19	0.08	6.56	0.02
SF36 energy	-0.14	0.07	3.50	0.08
role limitations due to physical health	-0.13	0.06	4.23	0.05

role limitations due to emotional health	0.09	0.045	4.26	0.05
sex	4.33	1.77	6.01	0.03
perceived concussion	3.87	1.70	5.16	0.04

Regression Model 10. Diagnosed concussions -- R-Squared = 0.94

Model CFQ-UA= - 0.17 (SF_{36}general health) + 0.17 (SF_{36}pain estimate) + 1.7 (Sex) + 2.25 (perceived concussion)

Variable	Parameter Estimate	Standard Error	F Value	Pr > F
SF_{36}general health	-0.17	0.03153	30.76	<.0001
SF_{36}pain estimate	0.17	0.03007	30.30	<.0001
sex	1.70562	0.79438	4.61	0.0431
perceived concussion	2.25442	0.74002	9.28	0.0059

Predictors of Diagnosed Concussion group

The predictors of SF-36 were included in the computed regression models 6-10 presented above for concussion group. SF-36 subscales *general health, pain,* and sex were persistent predictors of CFQ scores in all regression models 6-10 from. *Physical functioning* is a predictor in three of the models, while it is important to note that *general health,* as a predictor of CFQ scores, is interestingly not present in the non-concussed group.

Table 13: Backward Regression Model for Patient Health Questionnaire predictors of Cognitive Failure Questionnaire

Diagnosed concussion = No	Diagnosed concussion =Yes
SumCFQ= 11.09(Sex)+1.22(Somatic) **CFQ-UA=** 1.54(Sex)+0.16(Somatic) **CFQ-FTT**=4.09(Sex)+0.50(Somatic) **CFQ-FT=**1.75(Sex)+0.14(Somatic) **CFQ-AL**=3.70(Sex)+0.41(Somatic)	**SumCFQ**= 1.72(Somatic) -3.19(Anxiety) +2.89(Depression) **CFQ-UA**= 1.32(Sex) -0.70(Anxiety) + 0.89(Depression) + 0.42(Panic) **CFQ-FTT**= 0.67(Somatic) -1.25(Anxiety) +1.14(Depression) **CFQ-FT**=1.83(Sex) -0.69(Anxiety) +0.76(Depression)+0.40(Panic) **CFQ-AL**=0.73(Somatic) -2.30(E1)

In Table 13 the predictors of PHQ subscales: *Somatic, Anxiety, Depression and Panic* and their significance in predicting levels of cognitive failures using CFQ are shown. The two concussion groups differ on the predictors of the models. Levels of *anxiety, depressive and panic* symptoms on the PHQ predicted the concussed group's cognitive failures levels. Cognitive failures were impacted by levels of *anxiety, and depression* in the Sum CFQ score and three subscales of *unintended activation, failure to trigger and faulty triggering*, which was exclusive to the concussed group. The non-concussed group versus the concussed group showed predictors from solely *somatic* and sex variables in each model compared to the concussion group which had somatic and sex variables in the model but not together as predictors of cognitive failures.

Discussion

The purpose of this study was to determine the extent to which measures of self reported health status and quality of life, based on the PHQ and SF-36, could be used to evaluate cognitive failures in a sample of individuals age 40-65 reporting history of concussion.

The prevalence of concussions in this random sample of adults age 40-65 was evaluated against that which has been reported in the literature. According to King (2014), not only do females report more concussions than males, but the symptom severity also tends to be higher among females than among males. This was also shown in the present study, where females reported more concussions than males, and of those reporting concussions, females were more likely to report two or more concussions.

In the present study, the measure of cognitive failure was used to discriminate between the individuals that reported being concussed and those individuals reported never being concussed. While previous literature indicates that cognitive failure scores within the literature are below the present study's sample (Payne & Schnapp, 2014)(Pfeifer, Os, Hanssen, Delespaul, & Krabbendam, 2008), the sets of datum in the present study suggest that individuals who report a history of concussion are more likely to score higher on the Cognitive Failures Questionnaire. When this data were processed in separate regression models using health behaviors as predictors and controlling for concussion history it was apparent that the groups differed not only on the estimates of cognitive failures but also on the extent to which selected health behaviors predicted the likelihood to demonstrate cognitive failures. To draw inferences based on this data it is assumed that being healthy is a function of the interaction between the component parts of health -- based on the WHO (1948) that health is not merely the absence of disease or infirmity but the achievement of positive states of physical, social, emotional and spiritual influences.

In the sample of respondents the reports show there were direct relationships between measures on SF-36, PHQ and the Cognitive Failures Questionnaire scores that can aid in understanding the importance of health in a cohort of individuals with a history of concussion.

The present study demonstrated an inverse relationship between *pain subscale (SF-36)* and cognitive failures. This relationship was demonstrated using the *pain subscale (SF-36).* For example, the quality of life related to perceptions of pain was rated high (indicating an absence of pain) in all cohorts. This estimate suggests that respondents were not inhibited by sensations of pain, or that pain did not negatively impact their life. For example, the higher quality of life relative to pain estimator was positively correlated with the subscales of the CFQ, which represent *activation loss, failure to trigger and unintended activation (CFQ AL, CFQ- FTT, and CFQ-UA),* meaning higher cognitive failures were related to lower levels of pain. According to Bridger et al (2013) the ability to focus on certain tasks and goals is based on attentiveness, and therefore higher pain scores could be considered a distraction or a negative influence on attentiveness or stress. Given that high levels of pain could influence the ability to stay focused on selected cognitive tasks, pain was expected to act as a negative influence to scores on the CFQ, however this was not shown in the present study.

Variability

Initially, the analysis was intended to evaluate the magnitude of difference between diagnosed versus perceived concussion groups relative to the responses on the SF-36 (Health survey short form 36) and Cognitive Failure Questionnaire (CFQ). When comparing the means of each group on each subscale using t-tests and one-way ANOVAs, differences were not significant between mean scores of diagnosed or perceived concussion versus the non-concussed group. The lack of differences demonstrated on these scales may be attributed to the higher variability within the groups on each of the variables that comprise the subscales. Based on the high variability within groups and the low sample of respondents when separated by diagnosed and perceived concussion, the next step was to group individuals based on report of any history of concussion, and compare their mean scores on SF-36 subscales and CFQ with those who reported no history of concussion.

The groups (concussed versus non-concussed) were separated to test for differences in outcomes on the SF-36 and CFQ surveys. The separation of these cohorts was intended to evaluate these two important outcomes while controlling for the influence of concussion. However, it was also recognized that in creating the two groups, the information about frequency of concussion was combined in the concussed group and therefore could not be used to explain outcomes. The variability within the concussed group may have been intensified by the differences in number of concussions reported. Separating the data within the group of respondents reporting a concussion was not valuable because of the low number of participants in each sub-group relative to the variance estimates within the sub-groups. Further, it was also recognized that the accuracy of reporting concussion happened during a period of treatment and diagnostic regimens when different approaches were used than are practiced currently, and that while an individual may have been concussed previously, the accuracy of diagnosis may not have been similar between years or healthcare providers. Differences between each group of respondents that reported previous history of concussion were tested initially and since no differences were observed in this sample of respondents, the decision to combine all respondents that reported any concussion was made. The results of the simple linear regression analysis did not partition out the differences that were seen when means were compared between the two concussion groups, however when we performed separate regressions based on the concussion history the differences were no longer masked. Therefore, the differences found in the t-tests between concussed and non-concussed group is what led to the selection of a stratified model for the subsequent regression analyses.

Determining unique relationships

The PHQ subscale was used to measure symptoms relative to levels of: *depression, anxiety, and panic*. The present study demonstrated depression to be associated with CFQ scores. High levels of depression were correlated with high cognitive failures on the CFQ sum score, and subscale *failure to trigger and unintended activation (CFQ-FTT and CFQ-UA).* This finding is consistent with previous literature indicating that strategies used to perform cognitive activities are not adaptive in patients who report higher levels of depression (Bridger, 2013). Indicators of mental health symptoms seem to be reflective of an individual's ability to cope with certain situations and focus on daily cognitive tasks and goals. In Table 13, there is an apparent difference in the relationships that result from the statistical analyses between PHQ scores and CFQ scores in both groups. The presence of *depression, anxiety, and panic symptoms (PHQ)* as predictors in the concussed group is important, not only because these measures did not emerge in the group reporting never concussed, but because these measures are consistent with reports of other cases of severe head trauma in the literature (Hart, Kraut, Womack, Strain et al., 2013). The results from the regression modeling exercise for the present study suggest that there is a need to explore these relationships further.

Quality of life (QoL) (scores based on SF 36 scales) showed associations in a group of individuals who report being diagnosed with a concussion. *Physical health* played a role in further understanding this cohort. An outcome from the results of the present study is that *physical health (SF-36)* is impacted by the history of concussion. Overall *physical health (SF-36)* and diagnosed concussion showed a negative relationship ($p<.0001$), while scores of *pain (SF-36)* (pertaining to physical pain symptoms) show a negative relationship with concussion history. It was also observed that *social functioning (SF-36)* mean scores were found to be lower in relation to the Canadian population (SF M=86.4, SD=20.3) (Hopman, 2000). The respondents in the present study tended to demonstrate support for high levels of *pain* and low levels of *social functioning* creating a lower QoL. Comparatively, Spira (2014) reported that history of concussion demonstrates lower quality of life (QoL), and higher depression and stress on health measures (Spira, 2014).

Unique predictors for concussion: Pain and Physical Health

The results specifically for the group of concussed individuals in the present study demonstrated higher levels of *physical functioning (SF-36),* and based on their perception of health, these individuals were less likely to perceive or report physical pain. It is also suggested that these individuals continue to experience more positive physical functioning than the cohort of non-concussed individuals. These results demonstrate the relationship between physical and emotional measures of QoL using the SF-36. *Physical health and physical functioning (SF-36)* seems to be negatively related to pain, therefore those who experience high levels of pain demonstrate lower levels of physical health and physical functioning. Conversely, individuals who reported experiencing lower levels of *pain (SF-36)* demonstrated higher scores of *physical health and physical functioning (SF-36).* These relationships are connected to the Cognitive Failure Questionnaire as follows: although *physical functioning* was high and *pain* levels were low the reports of *emotional health (SF-36)* were included as significant predictors of cognitive failures in the group reporting previous diagnosis of concussion.

Emotional health, general health and role limitations due to emotional health (SF-36) were also negatively correlated with previously diagnosed concussions. The emergent pattern showed that QoL in the concussion group may have impacted how individuals perceived their limitations due to *physical health (pain, & energy)(SF-36).* This relationship may lead to the recognition and reporting of emotional symptoms in this group of individuals. Further with regard to cognitive functioning and history of concussion, Wilhelm (2010) introduced the concept of stress vulnerability. Wilhelm suggested that individuals that experience high cognitive failures might be vulnerable to high levels of stress that cause distraction and inhibit the ability to access coping abilities. This leads to compounded distracted behaviours, which may prevent the individual from completing cognitive tasks. In the present study, the results indicate that individuals that have experienced concussion in the past score higher on the CFQ, and although they remain physically active, they also showed a reduced quality of life relative to both *mental health (SF 36 subscale mental health) and emotional health (PHQ depression subscale)*.

Predictors of the CFQ in Concussed and Non-Concussed Respondents

The CFQ and the SF-36 demonstrated a relationship with *energy subscale (SF-36)* and CFQ subscales in both concussed and non-concussed groups. The *energy subscale* was negatively correlated with the CFQ subscales: *activation loss (CFQ-AL)* in the non-concussed group, and with CFQ sum score, and subscales: *activation loss and faulty triggering* in the concussed group. This is interesting, however while the relationship was negative in both groups, there were more significant pairwise correlations within the concussed versus non-concussed group. The non-concussed group *energy subscale (SF 36)* was negatively correlated to CFQ subscale: *activation loss (CFQ-AL)* but in the concussed group *energy subscale (SF 36)* was negatively correlated with CFQ sum score, and subscales : *activation loss (CFQ-AL) and failure to trigger (CFQ-FTT)*. These findings are consistent with previous literature by Meccaci (2006) where the CFQ demonstrated correlations with performance in attention tasks. The four subscales of the Cognitive Failure Questionnaire represent specific types of cognitive functions. These functions are classified according to whether an action is intended or not and whether an action is carried out or not. A negative correlation between *energy subscale (SF 36)* and CFQ subscales indicate that higher levels of energy are associated with fewer failures of intent or action. In the present study more types of failures for the CFQ classifications were found in the concussed group versus the non-concussed group; and in the concussed group, individuals that reported low on the *energy subscale (SF 36)* also showed higher cognitive failures on cognitive tasks. From the present study's results it can be inferred that individuals who have experienced concussions in the past are more likely to make mistakes and slips in actions when their energy levels are low, and although this needs to be further explored with additional cognitive measures, concussion could play a role in this slowing of recovery from activities that require physical and cognitive energy.

Regression models and predictors distinct for concussion and non-concussion groups

In the present study, ordinary least squares regression, based on a backward elimination approach was used to determine relationships between CFQ variables and the predictor variables that included scores on the SF-36 and the PHQ, in each of the non-concussed and previous history of concussion groups. The results for each group based on their concussion history were not only different in the variables that were selected to describe the CFQ subscale scores, but the level of variance explained within the CFQ subscales by the sets of predictor variables within each concussed group were also different. For example, when using the CFQ sum score as a dependent variable in the non-concussed group the significant predictor variables included *pain, role limitation due to emotional health (SF-36), and sex*. However, in the diagnosed concussion group the predictor set included: *general health, pain, physical functioning (SF-36)*, *sex and perceived concussions*. Understanding measures of *physical functioning* in the group reporting a history of concussion is of interest as it may intimate that this group is active and continues to develop pursuits of physical functioning (increase in *physical functioning (SF-36*)) regardless of the risk of concussion. Likewise, although not confirmed by the data collected in this study, it may be that individuals reporting history of concussion may be associated with a more active lifestyle compared to those with no prior history of concussion, implicating a relation to increased reports of concussion.

The regression models for the Patient Health Questionnaire (PHQ) and Cognitive Failure Questionnaire (CFQ) showed differences in significant variables between the concussed and non-concussed group. For example, for the CFQ sum score and all subscales except *unintended activation (CFQ-UA),* anxiety and depression were significant in all models, showing the influence that symptoms of anxiety and depression can have on cognitive failures, or tendency to report cognitive failure. The results of the present study do not indicate that symptoms of anxiety and depression are higher for the concussed group but the results highlight the negative influence of measures of anxiety and depression symptoms on the ability to complete cognitive tasks with fewer failures. Wilhelm (2010) demonstrates positive correlations between CFQ and Beck Depression Inventory, and an increase in CFQ scores observed in patients treated for depressive and anxiety disorders (Kocalevent, 2013). PHQ subscales: *somatic and depressive* symptoms also demonstrate correlations with SF-36: *Mental and Physical health component scores* (Kocalevent, 2013). Interestingly, PHQ: *panic scale* is a predictor in the model CFQ subscale*: unintended activation (CFQ-UA)* (associated with failures or actions, where an action was carried out but not intended, and caused by internal causes). The present study is not proposing that the concussed group is more likely to report *somatic, panic, depression or anxiety symptoms (PHQ)* but that these symptoms are an indication of cognitive failures in the concussed group.

Concern for health and future impact

The SF-36 provides subscales for *physical functioning, role limitations due to physical health and an overall physical health score*. Contrary to what was expected the concussed group did not report higher scores on the subscale: *limitations due to physical health (SF-36)* compared to the non-concussed group, and the group had a tendency to report higher scores of *physical functioning(SF-36)* in relation to the CFQ, assuming these individuals were presumably athletes who had experienced concussion while participating in physical activity.

The present study demonstrated high *limitations due to physical health (SF-36)* that were uniquely related to lower cognitive failures in the concussion group. These findings were not observed in the group of respondents that reported never having experienced a concussion. The findings suggest that although reporting low physical limitations, individuals that reported history of concussion(s) also reported a tendency to score higher on the CFQ. Inferences cannot be drawn on the cognitive state of these individuals but the tendency to score higher on cognitive failures is indicative of individuals with a concern about their current health with respect to their cognitive level and/or the extent to which a history of past concussions will affect their future cognitive functioning, or a general level of awareness for personal cognitive abilities (Wilhelm, 2010). Wilhelm (2010) discussed the relationship between CFQ scores and dysfunctional levels of self consciousness, reflecting the idea that individuals with inappropriate worries about their health will present with ‘idiosyncratic failure episodes’ and complaints based on cognitive health. This may be an influencing factor among the respondents in the present study and may have had a latent influence on the symptoms reported.

Finally, it is noteworthy that the regression models for the concussion group included estimates of *general health (SF-36)* as a significant contributor to the CFQ score. These findings not only highlight the differences in the two response cohorts relative to the CFQ, but also suggest that individuals with a history of concussion could be attentive to their health, and again, in support of the previous comments by Wilhelm (2010), are more likely to attend to personal health given that they may feel vulnerable as a result of previous injuries.

Conclusion

With the increasing distribution of information related to concussion injuries there is a growing societal awareness that physical activities could result in trauma to the head, possibly causing long term impacts on neural system functioning. This awareness, in addition to the catastrophising reports by the media, has led to an increase in general anxiety among individuals that have experienced a concussion injury in their past athletic pursuits. The results of the present study support the notion that individuals that have experienced head trauma in the past might respond differently on measures of cognitive functioning when compared to individuals that reported never having experienced a concussion.

The data presented in the present research study are based on self-reports and demonstrate associations within the two cohorts - those reporting previous concussions versus those reporting never having experienced a concussion, and as such may highlight a select group of individuals within the general population. Emotional and physical health measures were predictors in models of concussions that were not present in the non-concussion group. The cause of these underlying mental health symptoms are not explicit but may be attributed to worry about the impacts concussion can cause. The fact that different predictive equations were observed between the two groups suggests that there are intrinsic differences in the two comparison cohorts, which need to be explored further.

Limitations and Future Research

A major limitation recognized in the present study was that the data were dependent on self-report for all measurements. The limitation related to this approach is that respondents were anonymous since they were reporting via the Internet (No follow-up or ability to inquire further information). Despite the issues of security and control of data entry, it is important to accept that the individual was intrinsically motivated to complete the surveys and had a genuine interest in the study. A secondary limitation of the data collected in this thesis is that they represents only those individuals that took the time to respond to the web-based surveys and thereby excluded individuals that did not have access to a computer or interest in replying online.

Data collection may have been limited as the topic of concussion may have attracted those who were interested in long-term impacts of concussions or had experienced a concussion injury in the past. Individuals who completed the surveys may have had concerns about the effect of a concussion injury on their cognitive functioning in the future and the potential to develop dementia in the senior years.

There is a general recognition that concussive injury influences cognitive functioning (Hart, 2014), as such, there is a need to reconsider the mechanisms of concussion and the subsequent long-term effects of concussion injury on general neural system functioning. It is therefore recommended that future research establish precise and reliable estimates of changes in neural system functioning -- e.g. memory loss, cognitive functioning, and neural processes of the central nervous system, that may be affected by head trauma. Further, there is a need to provide more evidence to support relationships between head trauma outcomes and generalized measures of health status, from self-reports.

References

Abrahams, S., Mc Fie, S., Patricios, J., Posthumus, M., & September, A. V. (2014). Risk factors for sports concussion: An evidence-based systematic review. *British Journal of Sports Medicine, 48*(2), 1-9. Retrieved from: http%3a%2f%2fsearch.ebscohost.com%2flogin.aspx%3fdirect%3dtrue%26db%3ds3h%26AN%3d93333338%26site%3deds-live%26scope%3dsite

Ahman, S., Saveman, B., Styrke, J., Björnstig, U., & Stålnacke, B. (2013). Long-term follow-up of patients with mild traumatic brain injury: A mixed-method study. *Journal of Rehabilitation Medicine, 45*(8), 758-764. doi:10.2340/16501977-1182

Bridger, R., Johnsen, S., & Brasher, K. (2013). Psychometric properties of the Cognitive Failures Questionnaire . Ergonomics, 56(10), 1515-1524.

Broadbent, D. E., Cooper, P. F., FitzGerald, P., & Parkes, K. R. (1982). The cognitive failures questionnaire (CFQ) and its correlates. British Journal of Clinical Psychology, 21(1), 1-16

Brooks, B. L., McKay, C. D., Mrazik, M., Barlow, K. M., Meeuwisse, W. H., & Emery, C. A. (2013). *Subjective, but not objective, lingering effects of multiple past concussions in adolescents*

Buck, P. (2011). Mild Traumatic Brain Injury: A Silent Epidemic in Our Practices. *Health & Social Work, 36*(4), 299-302

Cairney, J., Kwan, M. Y. W., Veldhuizen, S., & Faulkner, G. E. J. (2014). Who uses exercise as a coping strategy for stress? results from a national survey of canadians. *Journal of Physical Activity & Health, 11*(5), 908-916. Caron, J. G., Bloom, G. A., Johnston, K. M., & Sabiston, C. M. (2013). Effects of multiple concussions on retired national hockey league players. *Journal of Sport & Exercise Psychology, 35*(2), 168-179.

Caron, J. G., Bloom, G. A., Johnston, K. M., & Sabiston, C. M. (2013). Effects of multiple concussions on retired national hockey league players. *Journal of Sport & Exercise Psychology, 35*(2), 168-179

Chrisman, S. P. D., & Richardson, L. P. (2013). Original article: Prevalence of diagnosed depression in adolescents with history of concussion. *Journal of Adolescent Health,* doi:10.1016/j.jadohealth.2013.10.006

Clay, M. B., Glover, K. L., & Lowe, D. T. (2013). Concussion special issue: Epidemiology of concussion in sport: A literature review. *Journal of Chiropractic Medicine, 12*, 230-251. doi:10.1016/j.jcm.2012.11.005

Daneshvar, D. H., Riley, D. O., Nowinski, C. J., McKee, A. C., Stern, R. A., & Cantu, R. C. (2011). Long-term consequences: Effects on normal development profile after concussion. *Physical Medicine & Rehabilitation Clinics of North America, 22*, 683-700. doi:10.1016/j.pmr.2011.08.009

De Beaumont, L., Brisson, B., Lassonde, M., & Jolicoeur, P. (2007). Long-term electrophysiological changes in athletes with a history of multiple concussions. *Brain Injury, 21*(6), 631-644. doi:10.1080/02699050701426931

de Sousa, C. V., Magalhães Sales, M., Vila Nova, d. M., de, O. R., Cruz, d. S., & Petriz, d. A. (2014). Sedentary life style is associated with an elevated perceived stress. *Journal of Exercise Physiology Online, 17*(6), 90-96.

Feeny, D., Garner, R., Bernier, J., Thompson, A., McFarland, B. H., Huguet, N., . . . Blanchard, C. M. (2014). Physical activity matters: Associations among body mass index, physical activity, and health-related quality of life trajectories over 10 years. *Journal of Physical Activity & Health, 11*(7), 1265-1275.

Ghanbarian, A., Ghaleh, N., Delshad, M., Amirshekari, G., Askari, S., & Azizi, F. (2015). Reliability and validity of the modifiable activity questionnaire for an Iranian urban adolescent population. *International Journal of Preventive Medicine Int J Prev Med,* (6), 3-3. Retrieved August 3, 2015.

Hart, J., Kraut, M., Womack, K., Strain, J., Didehbani, N., Bartz, E., . . . Cullum, C. (2013). Neuroimaging of Cognitive Dysfunction and Depression in Aging Retired National Football League Players. JAMA Neurology, 70(3), 326-335.

Hopman, W. M., Berger, C., Joseph, L., Towheed, T., VandenKerkhof, E., Anastassiades, T., . . . Papadimitropoulos, E. A. (2006). The natural progression of health-related quality of life: Results of a five-year prospective study of SF-36 scores in a normative population. *Quality of Life Research, 15*(3), 527-536. doi:10.1007/s11136-005-2096-4

Humphreys, B. R., McLeod, L., & Ruseski, J. E. (2014). Physical activity and health outcomes: Evidence from canada. *Health Economics, 23*(1), 33-54. doi:http://onlinelibrary.wiley.com/journal/10.1002/%28ISSN%291099-1050/issues

Knight, R., McMahon, J., Green, T., & Skeaff, C. (2004). Some normative and psychometric data for the geriatric depression scale and the cognitive failures questionnaire from a sample of healthy older persons. *New Zealand Journal of Psychology, 33*(3), 163-170.

King, D., Brughelli, M., Hume, P., & Gissane, C. (2014). Assessment, management and knowledge of sport-related concussion: Systematic review. *Sports Medicine, 44*(4), 449-471.

Kocalevent, R., Hinz, A., & Brähler, E. (2013). Standardization of a screening instrument (PHQ-15) for somatization syndromes in the general population. *BMC Psychiatry,* 91-91.

Kriska, A., Knowler, W., Laporte, R., Drash, A., Wing, R., Blair, S., . . . Kuller, L. (1990). Development of Questionnaire to Examine Relationship of Physical Activity and Diabetes in Pima Indians. *Diabetes Care, 13*(4), 401-411.

Kroenke, K., Spitzer, R., & Williams, J. (2002). The PHQ-15: Validity of a New Measure for Evaluating the Severity of Somatic Symptoms. *Psychosomatic Medicine,* 258-266.

Kroenke, K., Spitzer, R. L., Williams, J. B. W., & Löwe, B. (2010). *Psychiatry and primary care: The patient health questionnaire somatic, anxiety, and depressive symptom scales: A systematic review* Elsevier Inc. doi:10.1016/j.genhosppsych.2010.03.006

Larson, G. E., & Alderton, D. L. (1997). *Further evidence on dimensionality and correlates of the cognitive failures questionnaire* Wiley-Blackwell.

Lobo, A. (2011). *Physical activity and health in the elderly*. S.l.]: Bentham Science Publishers.

Löwe, B., Decker, O., Müller, S., Brähler, E., Schellberg, D., Herzog, W., & Herzberg, P. (2008). Validation and Standardization of the Generalized Anxiety Disorder Screener (GAD-7) in the General Population. *Medical Care,* 266-274.

Luo, J., Nguyen, A., Villeda, S., Zhang, H., Ding, Z., Lindsey, D., . . . Wyss-Coray, T. (2014). Long-term cognitive impairments and pathological alterations in a mouse model of repetitive mild traumatic brain injury. *Frontiers in Neurology, 5*, 1-13. doi:10.3389/fneur.2014.00012

Mainwaring, L., Bisschop, S., Green, R., Antoniazzi, M., Comper, P., & Kristman, V. (2004). Emotional Reaction of Varsity Athletes to Sport-Related Concussion. PsycEXTRA Dataset, 26(1), 119-135.

Mainwaring, L., Hutchison, M., Camper, P., & Richards, D. (2012). Examining emotional sequelae of sport concussion. *Journal of Clinical Sport Psychology, 6*(3), 247-274.

Martin, A., Rief, W., Klaiberg, A., & Braehler, E. (2006). Validity of the Brief Patient Health Questionnaire Mood Scale (PHQ-9) in the general population. *General Hospital Psychiatry,* 71-77.

Martinez, D., E. (2011). Research & science. bloodless concussion: The misunderstood injury. *Journal of the American Chiropractic Association, 48*(7), 16-36.

Matsalla, G. (2012). Physical activity and mental health: A holistic approach. *Wellspring, 23*(2), A1-A4.

Matthews, G., Coyle, K., & Craig, A. (1990). Multiple factors of cognitive failure and their relationships with stress vulnerability. *Journal of Psychopathology and Behavioral Assessment, 12*(1), 49-65.

Matthews, G., & Wells, A. (1988). Relationships between anxiety, self-consciousness, and cognitive failure. *Cognition and Emotion, 2*(2), 123-132.

Mayers, L. B. (2013). Outcomes of sport-related concussion among college athletes. *The Journal of Neuropsychiatry and Clinical Neurosciences, 25*(2), 115-119. doi:10.1176/appi.neuropsych.11120374

McCrea, M., Guskiewicz, K., Randolph, C., Barr, W. B., Hammeke, T. A., Marshall, S. W., . . . Kelly, J. P. (2013). Incidence, clinical course, and predictors of prolonged recovery time following sport-related concussion in high school and college athletes. *Journal of the International Neuropsychological Society: JINS, 19*(1), 22-33. doi:10.1017/S1355617712000872

McIntosh, A. (2014). Reflections on two decades of concussion research, policy and practice. *Journal of Science & Medicine in Sport, 18*, e118-e118.

McLeod, T. C. V., Bay, R. C., & Snyder, A. R. (2010). Self-reported history of concussion affects health-related quality of life in adolescent athletes. *Athletic Training & Sports Health Care: The Journal for the Practicing Clinician, 2*(5), 219-226.

Mecacci, L., & Righi, S. (2006). *Cognitive failures, metacognitive beliefs and aging*. Personality and Individual Differences, 40(7), 1453-1459.

Meyer, O. L., Castro-Schilo, L., & Aguilar-Gaxiola, S. (2014). Determinants of mental health and self-rated health: A model of socioeconomic status, neighborhood safety, and physical activity. *American Journal of Public Health, 104*(9), 1734-1741. Retrieved from http%3a%2f%2fsearch.ebscohost.com%2flogin.aspx%3fdirect%3dtrue%26db%3ds3h%26AN%3d97667010%26site%3deds-live%26scope%3dsite

Miranda, N. A. (2012). Post-concussion syndrome. *Physical Therapy Products, 23*(7), 18-21. Retrieved from http%3a%2f%2fsearch.ebscohost.com%2flogin.aspx%3fdirect%3dtrue%26db%3ds3h%26AN%3d80733863%26site%3deds-live%26scope%3dsite

Mosby, I. (2009). Mosby's medical dictionary (8th ed.). St. Louis, MO: Mosby

Moser, R., Iverson, G., Echemendia, R., Lovell, M., Schatz, P., Webbe, F., Ruff, R., Barth, J. (2007). Neuropsychological evaluation in the diagnosis and management of sports-related concussion□. *Archives of Clinical Neuropsychology, 22*(8), 909-916.

Pasanen, T. P., Tyrväinen, L., & Korpela, K. M. (2014). The relationship between perceived health and physical activity indoors, outdoors in built environments, and outdoors in nature. *Applied Psychology: Health and Well-being, 6*(3), 324-346.

Paul, G. (2014). Playing the long game. *NZ Rugby World,* (169), 64-68.

Paxton, R. J., Motl, R. W., Aylward, A., & Nigg, C. R. (2010). Physical activity and quality of life-the complementary influence of self-efficacy for physical activity and mental health difficulties. *International Journal of Behavioral Medicine, 17*(4), 255-263.

Payne, T., & Schnapp, M. (2014). The Relationship between Negative Affect and Reported Cognitive Failures. Depression Research and Treatment, 1-7.

PR Newswire Association LLC. *'How to improve recovery and long term effects of concussions'* (2014).

Purakom, A., Nakornkhet, K., Tanomsuk, M., Pupanead, S., Seabra, A., & Carvalho, J. (2014). Associations between physical activity, functional fitness, and mental health among older adults in nakornpathom, thailand. *Asian Journal of Exercise & Sports Science, 11*(2), 25-35.

Robbins, C. A., Daneshvar, D. H., Picano, J. D., Gavett, B. E., Baugh, C. M., Riley, D. O., . . .

Stern, R. A. (2014). Self-reported concussion history: Impact of providing a definition of concussion. Open Access Journal of Sports Medicine, 5, 99-103.

Riddle, D. (2007). Brain aging: Models, methods, and mechanisms. Boca Raton: CRC Press.

Romain, J. E., & Taraman, S. (2014). Concussions impact adolescents' mental health: Be aware of the neurologic, cognitive, and psychiatric symptoms of concussion International Medical News Group.

Ruhe, A., Gänsslen, A., & Klein, W. (2014). The incidence of concussion in professional and collegiate ice hockey: Are we making progress? A systematic review of the literature. *British Journal of Sports Medicine, 48*(2), 1-5.

Spira, J. L., Lathan, C. E., Bleiberg, J., & Tsao, J. W. (2014). The impact of multiple concussions on emotional distress, post-concussive symptoms, and neurocognitive functioning in active duty united states marines independent of combat exposure or emotional distress. *Journal of Neurotrauma, 31*(22), 1823-1834.

Stanton, R., Happell, B., & Reaburn, P. (2014). The mental health benefits of regular physical activity, and its role in preventing future depressive illness. *Nursing: Research & Reviews, 4*, 45-53. doi:10.2147/NRR.S41956

Staub, B., Doignon-Camus, N., Després, O., & Bonnefond, A. (2013). Sustained attention in the elderly: What do we know and what does it tell us about cognitive aging*? Ageing Research Reviews*, 12(2), 459-468.

Stults-Kolehmainen, M., & Sinha, R. (2014). The effects of stress on physical activity and exercise. *Sports Medicine, 44*(1), 81-121.

van Doorn, R. R. A., Lang, J. W. B., & Weijters, T. (2010). Self-reported cognitive failures: A core self-evaluation? *Personality and Individual Differences, 49*, 717-722. doi:10.1016/j.paid.2010.06.013

Walters, S. J., & Brazier, J. E. (2003). What is the relationship between the minimally important difference and health state utility values? the case of the SF-6D. *Health & Quality of Life Outcomes, 1*, 4-8.

WHO (1948). Preamble to the constitution of the world health organization as adopted by the international health conference. New York, 19-22 June, 1946; signed on 22 July 1946 by the representatives of 61 States (Official Records of the World Health Organization, no. 2, p. 100) and entered into force on 7 April 1948.

Wilhelm, O., Witthöft, M., & Schipolowski, S. (2010). Self-Reported Cognitive Failures. *Journal of Individual Differences*, 31(1), 1-14.

Appendix

Appendix A:

Approval of Ethics letter

1.1 Letter of consent

Measuring the relationship between self-reported concussion injuries and current states of general health, physical activity participation, and a general measure of cognition among individuals aged 40-65 years in the general population

Please read this information carefully and ask as many questions as you like before you decide whether you want to participate in this study. You are free to ask questions at any time before, during or after you agree to participate in this study.

Why have I been asked to participate?

You have been asked to participate because you are among the specific target populations identified within the scope of this research program. You are between the ages of 40 and 65 and are willing to complete the surveys in this study.

What is the purpose of this study?

The purpose of this study is to determine the influence of physical activity as a protective factor against late life cognitive decline using The Shankle Memory Test and the onset of emotional symptoms using the Beck Depression Index in a cohort of adults aged 40-65 years.

Do I have to take part in this study?

Your participation in any part of this research is voluntary. You may refuse to participate in this research. You may withdraw from this research at any time. If you choose to withdraw from this research, any data you have already provided may be retained and used for the purposes of this research.

The proposed research is intended to establish the value of selected tests as contributors to our understanding of the influence of physical activity as a protective factor for cognitive functioning and emotional symptoms in the 40-65 year age cohort.

Volunteers will complete six specific surveys related to physical activity participation, health, anxiety, and depression, using a customized online data collection tool.

It is expected that results of these investigations will provide essential information about the protective effects of physical activity involvement as an accurate and fundamental source of information.

This information sheet is yours to keep and is also available on the website. You can save or print a copy of the consent form from the website for your records.

If you take part and change your mind, you have the option of withdrawing from the process at any point without giving any reasons.

Submitting responses is considered your virtual agreement to the terms of the research process which are specifically noted as:

All information collected throughout this research process will remain confidential and securely stored using a firewall-protected secure server accessible via password for security and safety at the University of Prince Edward Island for a period of five years.You are NOT obligated to complete any forms, and you may withdraw from the research process at anytime.

What will I have to do if I agree to take part?

If you choose to participate we will ask you to sign-in and then complete a series of web based forms which may take approximately 30 minutes depending on your responses.

Are there any possible disadvantages from participating?

There are no reasonable foreseeable discomforts or risks involved in participating as you could respond to the web based surveys at any time and place. The website will be monitored and backed up by the baseline screening process technical support team at the University of Prince Edward Island. If there is any unexpected discomfort, disadvantage or risk to you during the course of this process, please, bring it to the attention of Dr. William Montelpare, to help you find support.

There are no known risks or harm with this research process. If you have any problems with the ethical conduct of this study please send an e-mail to reb@upei.ca or call (902) 620-5104.

What are the possible benefits from taking part?

There are no immediate benefits for those participating in the research process, but the data will contribute to the knowledge base and inform the research process support team about events that occur during the process. You may gain some personal benefits or support from being a part of this research process and contributing specific feedback about the process and the outcomes. In addition, the data will be used as part of the graduate studies experience for students that are part of the technical data collection team.

Will my participation be kept confidential?

Yes, all information collected will be kept strictly confidential. You will be assigned a personal identification number (ID) or pseudonyms to identify your responses. Personal identifiers will be removed from responses during the analysis of the data and replaced with pseudonyms. During the study Dr. William Montelpare and members of the research team will have access to data that you submit. Your ID and details that you submit will be stored in a password-protected computer. Your test responses will not be held together with your personal details. Data will be stored on the University of Prince Edward Island firewall protected secure server that is only accessible via password for security and safety. After finishing this study the data will be stored in password protected computer of the baseline screening process supervisor (Dr William Montelpare) for 5 years and then destroyed according to the University policy on data protection.

What type of information will be sought and why the collection of this information?

The information we need will be detailed responses to the questions to assist us (the researchers) in establishing the statistical models using these measures. This information will help us to understand if this protocol can be used to determine the protective effects of regular participation in physical activities on cognitive effects in later life.

What will happen to the results of the research project?

A summary of the findings will be sent to all participants electronically and the selected members of the medical community where appropriate. Findings will be submitted for publication in peer reviewed journals and presented at academic and professional conferences.

Who is organizing and funding the research?

The study is being led by Dr. William Montelpare and Heidi O'Brien, BA. (M.Sc. Candidate) and is supported by research funding as part of his Research Chair as the Margaret and Wallace McCain Chair in Human Development and Health.

Who can I contact for further information?

For questions about this research please contact:

Heidi O'Brien, BA. Research Assistant, hobrien@upei.ca

or

Professor William J. Montelpare, Ph.D., Margaret and Wallace McCain Chair in Human Development and Health, Department of Applied Sciences, Faculty of Science, Health Sciences Building, University of Prince Edward Island, 550 Charlottetown, PE, Canada, C1A 4P3 (o) (902) 620-5186

You may copy this information sheet for future reference.

Some basic guiding principles for the partnership between the researchers and the participants I have read the information sheet for this study and have been given permission to print any information I wish. I have also been provided a contact number of the Principal Investigator and an invitation to ask questions about the study or my participation in the study.

I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my legal rights being affected and I give consent for any data already given to be retained and used.

I understand that I will not benefit financially if this study leads to the development of education and training or future research/education/technological developmental outcomes.

I know how to contact the study team if necessary. I understand that I can contact the UPEI Research Ethics Board at (902) 620-5104, or by email at reb@upei.ca if I have any concerns about the ethical conduct of this study.

I understand that by submitting the letter of informed consent with this study I am agreeing to participate in this study.

I understand that a written summary of the findings will be available to participants through reports produced by the study team and disseminated via professional and academic journals and conferences.

1.2

The Health Risk Factor Study

Masters of Science Thesis Project

You are invited to participate in a study of the protective effects of physical activity on cognitive decline and the onset of emotional symptoms. This study uses a retrospective research approach, which will require you to reflect on the volume of your physical activity involvement over the past 12 months. The study will measure the relationship between volume of physical activity, history of concussion, and current health status using standardized instruments of cognition, emotional health, and overall general health, among individuals aged 40-65 years in the general population

The main objective of the study is to measure current levels of physical activity as a predictor of cognitive, emotional, and general health status, and to investigate if the presence of concussion history has an impact on this relationship.

This research is supervised by Dr. William Montelpare and has been approved by The Research Board of Ethics at The University of Prince Edward Island.

It takes only a short time to complete surveys.

http://health.ahs.upei.ca/WP/wordpress/

Click on this link or paste it into your URL. Click on the The Health Risk Factor Study. Begin with the background information page and follow with the letter of informed consent before completing the six surveys.

We ask that participants complete the survey by January 30, 2015.

Thank you, for taking the time to support The Health Risk Factor Study.

If you have any questions regarding this feel free to contact:

Heidi O'Brien, BA., OR William Montelpare, Ph.D.,
Principal Investigator, Professor & Research Supervisor,
M.Sc. Graduate student Department of Applied Human Sciences,
hobrien@upei. wmontelpare@upei.ca
(902)393-5900 (902)620-5186

*All information collected throughout this research process will remain confidential and stored securely using a firewall-protected secure server accessible via password for security and safety at the University of Prince Edward Island for a period of five years. You are NOT obligated to complete any forms, and you may withdraw from the research process at anytime.

Appendix B: Questionnaires

Background information

Concussion History Questionnaire

Rand Health survey: Short Form: 36

The 36 questions in the SF-36 survey capture the subject's perception of their general health by sorting them into multi-item scales that assess 8 concepts. The 8 subscales are as follows:

Physical Functioning (PF) - assesses limitations on normal physical activities (lifting, climbing stairs, bending, knelling, walking moderate distance), designed to estimate the severity of the limitation. (10 questions)

Role/Physical (RP) - assesses limitation on the individual's work function that is caused by physical health problems. "Role" may apply to work or everyday responsibilities (a job, community activity or volunteer work) typical for a specific age. (4 questions)

Bodily Pain (BP) - assesses the severity of pain and the extent to which it interferes with daily activities. (2 questions)

General health (GH) - assesses physical health status (current and prior health), and has been documented to be a good predictor of health care expenditures. (10 questions)

Vitality/ Energy (VT) - assesses a subjective feeling of well-being including energy and fatigue. (4 questions)

Social Functioning (SF) – assesses the quantity and quality of interaction with others (social relationships), extending measurements beyond exclusively physical and mental health concepts. (2 questions)

Role/ Emotional (RE) – assesses limitations in the individual's work functions, but restrict the cause of the distinct from those caused by the physical problems. (3 questions)

Mental Health /Emotional well - being (MH) - assesses the 4 major mental health dimensions of anxiety, depression, loss of behavioral or emotional control and psychological well-being. (5 questions)

The SF-36 also provides 2 important summery measures of health-related quality of life: Physical Component Summary (PCS) and Mental Component Summary (MCS) scales. The strength of both scales lies in their ability to distinguish a physical from a mental outcome [5]. The items and dimensions in SF-36 were constructed using the Likert method of summated ratings. The raw score of each of the eight SF-36 dimensions was derived by summing the item scores, and converted to a value for the dimension from 0 (worst possible health state measured by the questionnaire) to 100 (best possible health state). The raw score was then re-calculated across the dimension as follows:

The PCS and MCS scores were calculated using the standard scoring algorithms [5-8].

Finally, all 8 scales were standardized to overall population norm using the norm base scale (NBS) algorithms (mean=50, SD=10 in the 1998 general U.S. population); higher scores represents better performance [9]. Multiple groups have agreed that the minimal clinically important changes in the mental and physical summary scores are roughly 2 to 2.5 points [10,11].

The Short-Form 12 (SF-12) Health Survey and the SF-8 Health Survey are shorter forms derived from the original SF-36 health survey and were developed in order to improve efficacy and lower costs. However, the SF-12 reproduces the eight-scale profile with fewer levels than SF-36 scales and yields less precise scores. The physical and mental summary scores for the SF-12 have been shown to correlate highly with the same summary scores from the SF-36.

Cognitive Failure Questionnaire

The following questions are about minor mistakes that everyone makes from time to time, but some of which happen more often than others.

Each question is ranked from 4-0 indicating 4=very often, 3=often, 2=occasionally, 1= very rarely 0= never.

1. Do you read something and find you haven't been thinking about it and must read it again?

2. Do you find you forget why you went from one part of the house to the other?

3. Do you fail to notice signposts on the road?
4. Do you find you confuse right and left when giving directions?
5. Do you bump into people?
6. Do you find you forget whether you've turned off a light or a fire or locked the door?
7. Do you fail to listen to people's names when you are meeting them?
8. Do you say something and realize afterwards that it might be taken as insulting?
9. Do you fail to hear people speaking to you when you are doing something else?
10.Do you lose your temper and regret it?
11.Do you leave important letters unanswered for days?

12.Do you find you forget which way to turn on a road you know well but rarely use?
13.Do you fail to see what you want in a supermarket (although it's there)?
14.Do you find yourself suddenly wondering whether you've used a word correctly?
15.Do you have trouble making up your mind?
15.Do you find you forget appointments?
17.Do you forget where you put something like a news- paper or a book?
18.Do you find you accidentally throw away the thing you want and keep what you meant to throw away - as in the example of throwing away the matchbox and putting the used match in your pocket?
19.Do you daydream when you ought to be listening to something?
20.Do you find you forget people's names?
21.Do you start doing one thing at home and get distracted into doing something else (unintentionally)?

22.Do you find you can't quite remember something although it's 'on the tip of your tongue'?
23.Do you find you forget what you came to the shops to buy?
24.Do you drop things?
25.Do you find you can't think of anything to say?

Patient Health Questionnaire

A. PHQ 15 – Somatic symptoms

During the last 4 weeks, how much have you been by any of the following problems?

Not bothered= (0), Bothered a little= (1), Bothered a lot= (2)

1. Stomach pain
2. Back pain
3. Pain in your arms, legs, or joints (knees, hips, etc.)
4. Feeling tired or having little energy
5. Trouble falling or staying asleep, or sleeping too much
6. Menstrual cramps or other problems with your periods
7. Pain or problems during sexual intercourse
8. Headaches
9. Chest pain
10. Dizziness
11. Fainting spells
12. Feeling your heart pound or race
13. Shortness of breath
14. Constipation, loose bowels, or diarrhea
15. Nausea, gas, or indigestion

B. GAD 7 Anxiety Symptoms

During the last two weeks how often have you been bothered by the following problems?

Not at all= 0, Several days= 1, More than half the days= 2, Nearly every day= 3

1. Feeling nervous anxiety or on edge
2. Not being able to stop or control worrying
3. Worrying too much about different things
4. Trouble relaxing

5. Being so restless that it is hard to sit still
6. Becoming easily annoyed or irritable
7. Feeling afraid as if something awful might happen

C. Questions about anxiety attacks

1. In the last 4 weeks, have you had an anxiety attack suddenly feeling fear or panic? YES or NO . If Checked No go to question E
2. Has this ever happened before?........................... YES or NO
3. Do some of these attacks come suddenly out of the blue that is, in situations where you don't expect to be nervous or uncomfortable?...........................YES or NO
4. Do these attacks bother you a lot or are you worried about having another attack?............YES or NO
5. During your last bad anxiety attack, did you have symptoms like shortness of breath, sweating, or your heart racing, pounding or skipping?...........YES or NO

D. PHQ 9 Depressive Symptoms

Not at all= 0, Several days= 1, More than half= 2, Nearly every day= 3

1. Little interest or pleasure in doing things
2. Feeling down, depressed, or hopeless
3. Trouble falling or staying asleep, or sleeping too much
4. Feeling tired or having little energy
5. Poor appetite or overeating
6. Feeling bad about yourself — or that you are a failure or have let yourself or your family down
7. Trouble concentrating on things, such as reading the newspaper or watching television
8. Moving or speaking so slowly that other people could have noticed? Or the opposite – being so fidgety or restless that you have been moving around a lot more than usual
9. Thoughts that you would be better off dead or hurting yourself in some way

E. If you checked off any problems on this questionnaire, how difficult have these problems made it for you to do your work, take care of things at home, or get along with other people?

Not difficult= 0, Somewhat difficult= 1, Very difficult= 2, Extremely Difficult=

Appendix C:

Appendix C Table 1:SAS giving ID

Back Ground ID	ID/ Name/ Age	Concussion History (D)	(P)		Recent Conc.	Sf36	CFQ	Phys. Act.	PHQ	Shankle	Alzheimers in the family
35	46	7				19	8	10	20	17	N
36	54	8				20	9	11	21	18	Y
37	56	9				22	11	13	23	20	N
38	48	10				21	10	12	22	19	N
39	57	11				23	12	14	26	21	N
40	55	14				24	14	18	27	22	Y
42	45	13	3	3	1994	27	15	17	29	24	Y
41	46	12	3	1	2004	28	16	16	28	25	N
44	43	15	2	1	1995	29	17	19	31	26	Y
46	55	17				32	20	21	33	28	N
49**	43	19				34	22	23	35	30	N
50	58	20	3	1	2002	35	23	24	36	31	Y
51	57	21	2	2	1976 & 19	36	24	25	37	32	N
52	64	22	1	1	1983	37	25	26	38	33	Y
53	47	23	2	1	1991	38	26	28	39	34	N
54	43	24	1	1	1985	39	27	29	40	35	N
55	51	25				40	28	30	41	36	Y
56	62	26				41	29	31	42	37	Y
57	42	27				42	30	32	43	38	N
58**	43	28	1	1	2000	43	31	33	44	39	N
59	60	29	3	1	1977	44	32	34	45	40	Y
60	55	30				45	33	35	46	41	N
61	56	31				46	34	36	47	42	N
62	55	32				47	35	37	48	43	N
63	51	33	2	1	1993	48	37	38	50	45	Y
65	58	34				49	38	39	51	46	N
66	43	35				50	39	40	52	47	N

67	52	36				51	40	41	53	48	Y
68**	43	37				52	41	42	54	49	Y
69**	42	38				53	42	43	55	50	Y
70	62	39	3	1	1965	54	43	44	56	51	Y
71**	56	40	1	1	2011	55	44	45	57	52	N
72	65	41	1	1	1976	56	45	46	n/a	53	N
73	64	42	3	1	1998	57	46	47	58	54	Y
74	53	43				58	47	48	59	55	N
75	53	44				59	48	49	60	56	Y
77	53	45	3	2	2014	60	49	50	61	57	N
78	43	48	3	0	2013	61	50	51	63	58	N
79	59	49	5	5	1968	62	51	52	64	59	N
80	58	50				63	52	53	65	60	
81	57	52	1	1	1968	64	53	54	66	61	Y
83	44	54				66	55	56	68	63	N
84	42	55				67	56	57	69	64	N
87						70	54	60	71		N
89	45	59				71	58	61	73	66	N
91	51	61	1	1	1974	72	59	62	75	67	N
92	42	62				73	60	63	76	68	N
93	52	63	1	0	2003	74	61	64	77	69	Y
95	55	65				76	63	66	79	71	N
96	60 ID: 96	66				77	65	67	80	72	Y
97	45	67				78	64	68	81	73	Y
98	44	68	2	1	2012	79	66	69	82	74	Y
99	61	69				80	67	70	83	75	N
100	51	70				81		71	84		N
101		71	1	0	1978			72	85		N
102	46 ID:10 2	72	1	1	1999	82	68		86	76	Y
103	56	73	1	0	1985	83	69	73	87	77	N

105	51	75				85	70	74	89	78	Y
106	55	n/a				n/a			90		Y
107	56	n/a				n/a			92		Y
108	54					84			91		N
109	52	76				86	71	75	93	79	Y
110	56	77				87	72	77	94	80	Y
111	53	78				88	74	79	95	82	N
112	43	79				89	73	78	96	81	N
113	41	80	5	5	2012	90	75	80	97	83	N
117	60	82				92	76	82	100	84	N
118**	45	83				93	77	83	101	85	Y
121	51	84				94	80	85	102	88	N
123	53	85				95	79	84	103	86	N
124	59	86				96	81	86	104	89	N
125	54	87				97	82	87	105	90	N
126	43	88				98			106	87	N
127	51	89				99	83	88	107	91	N
128	52	90	5	2	1985	100	85	89	108	92	N
129	35	91	1	1	2010	101	84	90	109	93	N
130	54	92	2	1	1978	102	86	91	110	94	N
131	42	93				104	87	92	111	95	N
132	53	94	3	0	1990	105	88	94	112	97	N
133	58	95				107	89	95	113		N
135	61					109			114		N
136	52	96				108	90	98	115	98	N
138	62	99				110	91	99	117	99	N
140	46	102	3	1	1989	112	92	100	119	101	Y
141	52	103				113	93	101	120	102	N
142	74	104	1	0	1970	114	94	102	121	103	N
143	52	105				115	95	103	122	104	N
144	60	106				116	96	104	123	105	N
145	54	107	3	0	2011	117	97	105	124	106	N
146	55	108				118	98	106	125	107	N
147	61	109	2	0	1995	119	99	107	126	108	N

148	46	110	1	1	1973	120	100	108	127	109	N
150	51	111				121	101	110	128	110	N
151	55	112				122	102	111	129	111	N
152	56	113	2	1	1984	123	103	112	130	112	N
154	57	114				124	104	113	131	113	Y
155	57	115				125	105	114	132	114	N
156	49	116				126	106	115	133	115	N
157**	44	117	1	1	1983	127	107	116	134	116	N
158	45	118				128	108	117	135	117	N
159	58	119	1	1	1961	129	110	119	136	119	N
160	57	120				130	109	118	137	118	N
161	55	121				131		120	138	120	N
162	54	122				132	111	121	139	121	N
163	56	123				133	112	122	140	122	N
164	60	124				134	113	123	141	123	N
165**	48	125				135	114	124	142	124	Y
166	60	126	1	0	1997	136	115	125	143	125	N
167**	58	127				137	116	126	144	126	N
168	57	128	3	0	2006	138	117	127	145	127	N
169	50	129				139	119	128	146	128	Y
170	49	130				140	120	129	147	130	N

Table 1: Mean age- and sex-standardized scores for the 8 domains of the Medical Outcomes Study 36-item Short Form (SF-36) and for the 2 summary scales (physical and mental component) for Canadians

Age, yr	Physical functioning	Role physical	Bodily pain	General health perceptions	Energy/ vitality	Social functioning	Role emotional	Mental health	Physical component scale	Mental component scale
25–34	*n* = 399	*n* = 399	*n* = 399	*n* = 399	*n* = 398	*n* = 399	*n* = 399	*n* = 399	*n* = 398	*n* = 398
Mean score	92.4	87.1	77.0	79.0	64.9	86.3	82.9	75.9	53.0	50.1
SD	14.6	29.3	21.8	16.1	17.7	20.3	32.3	15.7	7.2	9.6
95% CI	91.0–93.9	84.3–90.0	74.9–79.1	77.4–80.6	63.2–66.6	84.3–88.3	79.8–86.1	74.3–77.4	52.2–53.7	49.2–51.1
% at floor*	0.5	7.2	0.3	0.04	0.2	1.0	8.2	0.3	0.7	0.2
% at ceiling*	55.4	80.7	29.5	10.5	0.6	57.0	75.2	1.1	0.3	0.2
35–44	*n* = 499	*n* = 499	*n* = 499	*n* = 499	*n* = 497	*n* = 499	*n* = 499	*n* = 498	*n* = 497	*n* = 497
Mean score	90.9	83.4	76.2	78.9	66.1	85.5	83.2	77.3	52.0	50.9
SD	15.1	31.6	22.1	16.9	17.4	18.4	32.5	14.7	8.0	9.0
95% CI	89.6–92.2	80.6–86.2	74.3–78.2	77.4–80.3	64.6–67.7	83.9–87.1	80.3–86.0	76/0–78.5	51.3–52.7	50.1–51.7
% at floor	0.1	7.8	0.2	0.2	0.3	0.3	9.8	0.1	0.1	0.1
% at ceiling	47.8	72.9	33.3	12.6	0.1	48.0	74.6	1.2	0.1	0.4
45–54	*n* = 1690	*n* = 1690	*n* = 1690	*n* = 1689	*n* = 1690	*n* = 1690	*n* = 1690	*n* = 1689	*n* = 1688	*n* = 1688
Mean score	88.0	84.9	76.2	77.3	65.5	86.4	85.6	76.8	51.3	51.4
SD	16.9	31.9	23.4	18.4	18.2	20.3	30.1	15.8	9.0	9.2
95% CI	87.2–88.8	83.3–86.4	75.1–77.3	76.4–78.2	64.6–66.4	85.5–87.4	84.2–87.1	76.0–77.5	50.9–51.7	51.0–51.8
% at floor	0.1	9.0	0.5	0.1	0.1	0.3	7.6	0.01	0.01	0.01
% at ceiling	36.1	77.9	34.5	11.0	0.7	56.6	77.8	3.2	0.1	0.01
55–64	*n* = 2282	*n* = 2282	*n* = 2282	*n* = 2276	*n* = 2280	*n* = 2282	*n* = 2282	*n* = 2279	*n* = 2271	*n* = 2271
Mean score	82.3	81.3	74.9	74.8	68.3	88.1	87.8	79.5	49.0	53.7
SD	19.3	33.1	23.7	19.4	17.7	18.8	28.3	14.7	9.2	8.2
95% CI	81.5–83.0	80.0–82.7	73.9–75.9	74.0–75.6	67.6–69.0	87.3–88.9	86.6–88.9	78.9–80.1	48.6–49.3	53.4–54.0
% at floor	0.2	9.2	0.2	0.1	0.4	0.2	6.3	0.03	0.02	0.0
% at ceiling	19.1	70.3	32.5	8.3	2.0	60.4	81.4	4.7	0.1	0.1
65–74	*n* = 2925	*n* = 2925	*n* = 2927	*n* = 2921	*n* = 2921	*n* = 2926	*n* = 2924	*n* = 2922	*n* = 2910	*n* = 2910
Mean score	75.7	76.2	74.0	73.5	67.7	87.0	83.4	79.3	47.2	53.7
SD	22.2	36.5	23.9	18.4	18.1	19.8	32.8	15.0	9.7	8.3
95% CI	74.9–76.5	74.9–77.5	73.1–74.8	72.8–74.1	67.0–68.3	86.2–87.7	82.2–84.6	78.8–79.8	46.8–47.6	53.4–54.0
% at floor	0.6	13.3	0.2	0.01	0.2	0.04	9.9	0.01	0.0	0.0
% at ceiling	9.1	63.8	31.9	4.6	2.7	58.8	76.3	7.3	0.0	0.01
≥ 75	*n* = 1613	*n* = 1609	*n* = 1614	*n* = 1611	*n* = 1613	*n* = 1612	*n* = 1612	*n* = 1613	*n* = 1603	*n* = 1603
Mean score	59.1	62.6	69.8	71.2	61.1	83.2	80.3	79.4	42.0	54.5
SD	27.4	41.9	25.1	17.9	19.6	22.5	34.3	15.1	10.3	8.6
95% CI	57.8–60.4	60.5–64.6	68.6–71.0	70.3–72.1	60.2–62.1	82.1–84.2	78.6–81.9	78.6–80.1	41.5–42.5	54.1–54.9
% at floor	1.3	23.7	0.3	0.2	0.4	0.7	11.3	0.01	0.03	0.1
% at ceiling	2.9	47.7	27.0	3.9	2.0	50.2	70.4	6.4	0.01	0.1
All ages	*n* = 9408	*n* = 9404	*n* = 9411	*n* = 9395	*n* = 9399	*n* = 9408	*n* = 9406	*n* = 9400	*n* = 9367	*n* = 9367
Mean score	85.8	82.1	75.6	77.0	65.8	86.2	84.0	77.5	50.5	51.7
SD	20.0	33.2	23.0	17.7	18.0	19.8	31.7	15.3	9.0	9.1
95% CI	85.4–86.2	81.5–82.8	75.1–76.0	76.6–77.3	65.4–66.1	85.8–86.6	83.3–84.6	77.2–77.8	50.3–50.7	51.5–51.9
% at floor	0.4	9.8	0.3	0.1	0.2	0.2	8.6	0.01	0.0	0.0
% at ceiling	36.7	72.7	31.8	9.7	1.0	54.9	76.1	3.0	0.01	0.0

Note: SD = standard deviation, CI = confidence interval.
*% at floor and % at ceiling refer to the proportion of respondents achieving the minimum (0) and maximum (100) possible scores respectively.

Within Scale Correlations

Appendix C Table 2: SF 36: Short form 36: Measure of Quality of life

	PF	RL1	RL2	E	EWB	SF	P	GH	PH	MH
PF	1.00	.28 P=.0032	.10 P=.28	.33 P=.0004	.32 P=.0009	-.16 P=.10	.48 P<.0001	.43 P<.0001	.66 P<.0001	.12 P=.2
RL1	-	1.00	.51 P<.0001	.46 P<.0001	.49 P<.0001	-.11 P=.25	..45 P<.0001	.48 P<.0001	.67 P<.0001	.41 P<.0001
RL2	-	-	1.00	.43 P<.0001	.50 P<.0001	-.01 P=.89	.25 P=.009	.25 P=.008	.34 P=.0003	.64 P<.0001
E	-	-	-	1.00	.70 P<.0001	-.19 P=.04	.44 P<.0001	.52 P<.0001	.56 P<.0001	.71 P<.0001
EWB	-	-	-	-	1.00	-.27 P=.005	.42 P<.0001	.47 P<.0001	.55 P<.0001	.66 P<.0001
SF	-	-	-	-	-	1.00	-.22 P=.02	-.22 P=.01	-.29 P=.002	-.24 P=.01
P	-	-	-	-	-	-	1.00	.40 P<.0001	.74 P<.0001	.22 P=.02
GH	-	-	-	-	-	-	-	1.00	.81 P<.0001	.33 P=.0006
PH	-	-	-	-	-	-	-	-	1.00	.29 P=.000

										7
MH	-	-	-	-	-	-	-	-	-	1.00

Appendix C Table 3: CFQ: Cognitive Failure Questionnaire within scale correlations

	CFQ	CFQ-al	CFQ-ft	CFQ-ftt	CFQ-ua
CFQ	1.00	.66 P<.0001	.58 P<.0001	.69 P<.0001	.63 P<.0001
CFQ-al	-	1.00	.78 P<.0001	.86 P<.0001	.82 P<.0001
CFQ-ft	-	-	1.00	.84 P<.0001	.78 P<.0001
CFQ-ftt	-	-	-	1.00	.82 P<.0001
CFQ-ua	-	-	-	-	1.00

Appendix C Table 4: PHQ Patient Health Questionnaire within scale correlations

	Somatic	Anxiety	Depression	Panic	E1
Somatic	1.00	.64 P<.0001	.69 P<.0001	.25 P=.005	.58 P<.0001
Anxiety	-	1.00	.67 P<.0001	.25 P=.005	.57 P<.0001

Depression	-	-	1.00	.22 P=.01	.67 P<.0001
Panic	-	-	-	1.00	.18 P=.05
E1	-	-	-	-	1.00

Appendix C Table 5: Mean comparisons for SF 36 subscales within the perceived concussion group and non concussion.

SF-36 Sub-scales	Never Concussed mean ± s (n = 69)	Perceived at least 1 Concussion mean ± s (n=17)	Perceived > 1 Concussion mean ± s (n=21)	One-way ANOVA F values* (p)
general health	71.66 ± 20.14	67.65 ± 16.04	75 ± 14.23	0.75 ns
physical functioning	87.97 ± 18.85	86.47 ± 10.86	91.36 ± 11.04	0.49 ns
role limitations (due to physical health)	86.33. ± 31.37	92.65 ± 14.7	84.52 ±31.10	0.61 ns
role limitations due to emotional health	88.88 ± 26.61	80.39 ± 35.47	92.42 ± 22.84	0.97 ns
pain	80.11 ± 17.42	82.5 ± 17.39	85 ± 16.31	0.71 ns
social functioning	59.78 ± 23.37	59.56 ± 15.64	52.84 ± 11.53	1.00 ns
energy/vitality	68.54 ± 16.96 (n=65)	63.53 ± 22.13	66.43 ± 21.46	0.50 ns

emotional health	77.39 ±17.89	80.00 ± 13.27	82.55 ± 11.68	0.90 ns

Appendix C Table 6: Mean comparisons within the perceived concussion group versus non concussion group for SF 36 component scales

Rand SF-36 Component Scores	Never Concussed mean ± s (n = 65)	Perceived at least 1 Concussion mean ± s (n=17)	Perceived > 1 Concussion mean ± s (n=21)	One-way ANOVA F values* (p)
Mental Health	75.07 ± 9.19	71.47 ± 16.60	69.67 ± 22.31	1.36 ns
Physical Health	84.88 ± 12.39	81.545 ± 12.63	75.95 ± 26.66	2.49 ns

Appendix C Table 7: Mean comparisons for diagnosed concussion group versus non concussion group for SF 36 subscales

SF-36 Sub-scales	Never Diagnosed with Concussion mean ± s (n =78)	Diagnosed with at least 1 concussion mean ± s (n= 29)	t test values* (p)
general health	71.54 ± 19.97	72.17 ± 14.30	-0.18 ns
physical functioning	88.40 ± 18.05	88.5 ± 11.46	-0.40 ns
role limitations (due to physical health)	86.54 ± 29.8	87.93 ± 28.05	-0.12 ns
role limitations due to emotional health	88.89 ± 26.19	86.67 ± 31.07	0.35 ns
pain	81.06 ± 16.99	82.58 ± 17.83	-0.40 ns
social functioning	58.97 ± 22.24	56.67 ±14.95	0.62 ns

energy/vitality	67.81 ± 18.52 (n=73)	66 ± 19.58	0.43 ns
emotional health	78.36 ± 17.15	80.13 ± 13.43	-0.57 ns

Appendix C Table 8: Mean comparisons for diagnosed concussion group versus non concussion group for SF 36 component scales

Rand SF-36 Component Score	Never Diagnosed with Concussion mean ± s (n =78)	Diagnosed with at least 1 concussion mean ± s (n= 30)	t test values*
Mental Health	73.79 ± 12.72	72.35 ± 17.23	0.42 ns
Physical Health	84.07 ± 14.75	78.71 ± 20.00	1.33 ns

Appendix C Table 9: Mean comparisons within the perceived concussion group versus non concussion group for CFQ sum score and subscales

CFQ Categories	Never Concussed mean ± s (n = 64)	Perceived at least 1 Concussion mean ± s (n=16)	Perceived > 1 Concussion mean ± s (n=20)	One way ANOVA F values* (p)
CFQ Sum Score	53.52 ± 16.16	50.19 ± 17.23	57.15 ± 16.30	0.82 ns
CFQ Activation Loss	17.91 ± 4.67	17.44 ± 5.42	18.65 ± 4.87	0.30 ns
CFQ Faulty Triggering	6.97 ± 2.80	6.44 ± 2.78	7.50 ± 2.35	0.69 ns
CFQ Failure to Trigger	21.25 ± 7.23	19.63 ± 7.16	22.30 ± 6.59	0.64 ns

CFQ Unintended Activation	7.39 ± 2.96	6.69 ± 2.98	8.70 ± 3.67	2.06 ns

Appendix C Table 10: Mean comparisons for diagnosed concussion group versus non concussion group for CFQ sum score and subscales

CFQ Categories	Never Diagnosed with Concussion mean ± s (n = 72)	Diagnosed with at least 1 concussion mean ± s (n=28)	t test* (p)
CFQ Sum Score	53.19 ± 16.42	55.04 ± 16.33	-0.51 ns
CFQ Activation Loss	17.83 ± 4.83	18.36 ± 4.78	-0.49 ns
CFQ Faulty Triggering	6.92 ± 2.77	7.18 ± 2.57	-0.45 ns
CFQ Failure to Trigger	21.13 ± 7.29	21.40 ± 6.60	-0.18 ns
CFQ Unintended Activation	7.32 ± 2.93	8.11 ± 3.64	-1.02 ns

Appendix C Table 11: SF 36 Backward Elimination with PHQ patient health questionnaire subscales

General health	= 3.27 (Somatic) -1.85 (Depression)
Physical functioning	= 3.83 (Somatic) -1.32 (Anxiety) -6.53(E1)
Social functioning	= 2.53 (Somatic) -1.32 (Anxiety)
Energy	= 3.12 (Somatic) -1.87(Depression)
Role Limitation Physical	= 3.54 (Somatic) -11.83(E1)
Role Limitation Emotional	= 3.89 (Somatic) -18.73(E1)
Pain	= 3.26 (Somatic) -9.49 (E1)
Physical Health	= 3.85 (Somatic) -2.36 (Depression)

Mental Health	=3.49 (Somatic) -2.27 (Depression)