THESIS

SENSATION SEEKING, IMPULSIVITY, AND BIG FIVE PERSONALITY FACTORS AS PREDICTORS OF RISKY BEHAVIOR FOLLOWING CONCUSSION

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ABSTRACT

SENSATION SEEKING, IMPULSIVITY, AND BIG FIVE PERSONALITY FACTORS AS PREDICTORS OF RISKY BEHAVIOR FOLLOWING CONCUSSION

Sports-related concussion is a growing public health concern. With 30-50% of concussions remaining undiagnosed for a variety of reasons, it is crucial to identify risk factors and establish appropriate prevention and harm reduction strategies to prevent the risk of multiple concussions. Few studies have investigated personality factors as predictors of concussion and continued participation following an initial injury. However, research has concluded that personality likely plays a role in symptom reporting and post-injury behaviors that may put one at risk of additional injury and premature return to play. Most research on personality and health risk behaviors has focused on substance use, gambling, and criminal behavior, with little research done on personality, risky sports, and injury. The limited work in this area has concluded that the personality construct of sensation seeking is predictive of engagement in sports that have an increased risk for injury, while other constructs like impulsivity, are more predictive of injury once already participating in risky sports. The Big Five factors of personality differentially predict injury during sport such that openness to experience and extraversion predict risk-taking overall, while low levels of neuroticism and low levels of conscientiousness predict risky behavior during sport to different degrees depending on the sport studied. The current study found that sensation seeking dimensions, experience seeking and risk seeking, were positively associated with returning to play more quickly than others in the sample. Further, both of these dimensions were negatively predictive of use of protective behavioral strategies against incurring sports-related concussion. Risk seeking, attentional impulsivity, motor impulsivity, and non-planning impulsivity were found to be positively predictive of likelihood of reporting repeat sports-related concussions. Regarding the Big Five, conscientiousness was associated with taking longer to return to play, more protective behavioral strategy use, and a lower likelihood of reporting more than 1 sports-related concussion. These findings may be used in implementing individualized targeted prevention and intervention efforts for athletes. Future work should investigate the mechanisms underlying these relations, as well as include additional sports-related concussion risk factors.

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CHAPTER 1: INTRODUCTION

Sports-Related Concussion

Concussion, a form of mild traumatic brain injury, is a complex pathophysiological process that causes a sudden alteration in brain functioning due to direct or indirect biomechanical forces on the brain; while direct forces on the brain include contact with the head, indirect forces on the brain include those that may directly impact other parts of the body, with this force negatively impacting the brain as well (Edwards & Bodle, 2014; Harmon et al., 2013, Khurana & Kaye, 2012; Kimbler et al., 2011). Sports-related concussions, or those sustained while participating in contact or non-contact sport for competition or recreation, typically occur with less force than concussions sustained from falls or car accidents (Khurana & Kaye, 2012). Because of this, sports-related concussions are most often associated with altered consciousness and disorientation, as opposed to complete loss of consciousness. Common symptoms are frequently divided into four categories: physical, cognitive, emotional, and sleep, with more specific common symptoms including headache, dizziness, difficulty concentrating, feelings of confusion, balance problems, and irritability (Hanson et al., 2014). Symptoms can further be divided into early and late symptoms. Early symptoms evolve over a time span of minutes to hours, and typically spontaneously resolving in minutes to days following impact (i.e. memory deficits including repeating questions, nausea, vomiting, vertigo, potential loss of consciousness, delayed responses (motor and verbal), confusion, inability to focus, emotions inconsistent with the situation, and slurred speech (Edwards & Bodle, 2014; Hanson et al., 2014). Late symptoms typically appear within days to weeks of the impact, and are largely longer lasting (i.e. depression, difficulty concentrating, persistent headache, etc.; Edwards & Bodle, 2014). Clinical diagnosis of sports-related concussion is most often made by a healthcare provider (e.g. athletic trainer) on site at the time of injury or after time has passed in a healthcare setting (Harmon et al., 2013).

Over the past several decades, sports-related concussion has become a growing public health concern (Asken et al., 2016). Between 1.6 and 3.8 million traumatic brain injuries occur in the United States each year while playing competitive sports and during recreational physical activities (Bryan et al., 2016). Bryan and colleagues report that 1.1-1.9 million of these injuries are sports-related concussions occurring in individuals 18 years old and younger. There are also a considerable number of undiagnosed concussions (Asken et al., 2016; Harmon et al., 2013). It is approximated that 30-50% of concussions go undiagnosed, resulting in a greater risk of potential post-concussive symptoms and premature return to play that could result in greater health consequences. With 44 million youth athletes participating in sports each year in the United States, there is growing need to determine risk factors for concussion.

Sports-related concussions occur most often in football, hockey, rugby, soccer, lacrosse, and basketball (Hanson et al., 2014; Harmon et al., 2013; Khurana & Kaye, 2012). These rates vary by a variety of factors including biological sex, position played, playing style, and type of injury (head-to-apparatus collision, body-to-body collision, head-to-surface collision, etc.). In sports with similar rules for males and females, females sustain more concussions on average (Kroshus et al., 2017). Chandran and colleagues (2017) found that the incidence of concussion due to body-to-body collision was not significantly different between females and males; however, females were 2.5 times more likely to sustain a concussion from a head-to-apparatus collision (e.g., head-to-ball) and were 2 times more likely to experience a concussion from head-to-surface contact (e.g., head-to-ground). In addition to the environmental, demographic, and personality factors (e.g., playing style) that contribute to the attainment of a sports-related concussion, these factors are also central to the likelihood of symptom reporting following injury.

Symptom Reporting

Individuals refrain from reporting symptoms of concussion for a variety of reasons (Asken et al., 2016). Athletes that do not report symptoms and continue playing are 2.2 times more likely to require a longer recovery period than those who immediately report symptoms and refrain from play. Asken and colleagues found that symptom reporting and removal from play is predictive of necessary recovery length. These researchers describe that immediate reporting resulted in shorter necessary recovery periods on average when compared to delayed reporting, even when controlling for sex, concussion history, learning disorder or attention deficit hyperactivity disorder (ADHD) diagnosis, other psychological disorder diagnosis, and immediate symptom severity. The likelihood of reporting symptoms, and the amount of time that an individual allows to pass before reporting, is most often determined by a drive to continue playing, pressure from coaches and parents, altered self-awareness that may result from the injury, a misunderstanding of what symptoms are severe enough to report, and the instance in which an athlete does not remember a specific occurrence in which they would have sustained a concussion (Asken et al., 2016; Delaney et al., 2015; Khurana & Kaye, 2012; Kimbler et al., 2011).

Kroshus and colleagues (2017) reported that females have a greater likelihood of intention to report symptoms post-injury than males, but there is no sex difference in the likelihood that a player will continue playing while symptomatic. Another differentiating factor between sexes is the adherence to the stereotypically masculine norm of greater risk-taking and a desire to win at all costs, with females who possess this trait more likely to continue playing while symptomatic than males. Adherence to gender norms in sport is suggestive of cultural factors affecting post-injury concussion behaviors such as reporting of concussion symptoms. Further, this evidence points to personality as a possible predictor for tendency towards performing in accordance with gender norms, and tendency towards risk-taking and aggressive behavior while participating in sport.

These factors affecting symptom reporting have contributed to the growing number of undiagnosed concussions in the United States. Meehan III and colleagues (2013) conducted a study in which 486 athletes who had just sustained a concussion were assessed for previous undiagnosed concussions, as well as current post-injury symptoms. Undiagnosed concussion was defined as a blow to the head that did not result in formal concussion diagnosis by a medical professional but resulted in one or more symptoms listed on the Post Concussion Symptom Scale (PCSS). Athletes reporting previously undiagnosed concussions were more likely to have lost consciousness as a result of their current injury and reported significantly higher mean Post Concussion Symptom Scale scores post-injury than those with no history of undiagnosed concussion. Of these athletes, 30.5% reported a previously undiagnosed concussion. Lack of symptom reporting is a possible contributor to undiagnosed concussion, and the likelihood of sustaining multiple concussions more broadly.

Multiple Concussions and Associated Risks

While concussions are potentially harmful in the short-term, incurring multiple concussions leads to a greater likelihood of damaging effects in the long-term (Khurana & Kaye, 2012). Individuals with two more concussions have a greater likelihood of adverse cognitive, behavioral, and sleep outcomes than peers with one concussion (Schatz et al., 2011). There is a period of post-concussive vulnerability (7-10 days) that highlights a range of time when an individual is most likely to experience adverse effects if another injury occurs (Khurana & Kaye, 2012; McCrea et al., 2009). There is evidence that greater adverse effects can occur after sustaining multiple concussions, especially within the period of vulnerability post-injury (Harmon et al., 2013). Injuries during this period can result in more severe symptoms as well as show worsening metabolic changes at the cellular level. Edwards and Bodle (2014) describe the uncommon short-term post-concussive effect of second impact syndrome. While uncommon, the adverse effects of this syndrome occur when multiple concussions are sustained during the vulnerable period following an initial head injury. Khurana and Kaye (2012) mention additional signs that an athlete is vulnerable to the worsening effects of multiple concussions; growing vulnerability to injury can be seen in those whose symptom severity is greater than the corresponding injury severity.

While second impact syndrome can be considered a more immediate consequence of concussion, more “medium-term” effects include post concussion syndrome symptoms like irritability, light-headedness, sleep disturbance, and persistent headache (Edwards & Bodle, 2014). At the more extreme end of the spectrum, the long-term effects of multiple concussions and chronic traumatic brain injury are a spectrum of disorders including chronic traumatic encephalopathy (CTE), post-traumatic parkinsonism, post-traumatic dementia, and more (Jordan, 2013). While these disorders are severe outcomes of chronic concussion and traumatic brain injury, the growing knowledge and popularity in this area highlights the associated risks. Much remains unknown about the effects of progression of these disorders, with some like CTE only possible to diagnose after death.

Return to Play

Part of the risk of multiple concussions that contributes to the period of vulnerability post-injury stems from premature return to play. McCrea and colleagues (2009) describe the necessity of a symptom-free waiting period before returning to play following a concussion. This waiting period entails concussion symptoms returning to baseline for an athlete, both at rest and during full activity, before they may resume activity at full capacity. They report that individuals who sustain repeat injuries adhere to the medically advised symptom-free waiting period following a concussion for 2.82 days less, on average, than those who do not sustain repeat injures. Harmon and colleagues (2013) discuss the suggestion of a gradual, stepwise progression in physical demand and risk of contact throughout the timeline for recovery. It is noted that premature return to play and lingering symptoms can lead to delayed reaction time and greater risk of further injury as a result. Khurana and Kaye (2012) discuss returning to play only after baseline, or pre-injury, scores are attained on neuropsychological and balance testing. The complete cessation of play is an entirely individualized process, with no reported standardized practice or protocol for the recommendation of no future return to play. This indicates a large degree of personal choice in many cases for return to activity, especially in recreational physical activities where there is typically less oversight. Edwards and Bodle (2014) mention the ambiguity that can come with the Return to Play Protocol. There is a need to balance the safety measure of keeping an athlete out long enough to heal, while also allowing them to return to activity as part of the recovery process. The degree to which this decision is individualized leaves a lot of the decision up to the individual and the practitioner through which they are seeking services. Many questions remain about which individuals are most at risk for premature return to play, as well as most likely to ignore proper preventative, protective, and harm-reduction behaviors and strategies.

Concussion Prevention

There have been efforts at concussion prevention including an emphasis on enforcing rules of fair play and following up to date return to play protocol (Hanson et al., 2014; Harmon et al., 2013). The protective behavioral strategies of increased education regarding concussion protocol and recovery, as well as more widespread information and education regarding signs and symptoms of concussion, are intended to prevent premature return to play and the increased risk of multiple concussions (Edwards & Bodle, 2014; Hanson et al., 2014). Teaching athletes to be more aware of possible collision, termed "collision anticipation", as well as informing them about the advantages of neck and posterior shoulder strengthening in concussion prevention have proven advantageous. There has been additional suggestion of changing the rules of some activities and sports to best protect against possible concussion. Other suggestions surround the use of helmets and mouth guards to physically protect the body from the harmful effects of impact (Hanson et al., 2014; Harmon et al., 2013). Both helmets and mouth guards have been shown to prevent death and more extreme impact injuries like lacerations, broken bones, and internal bleeding, but have not been shown to reduce the incidence and severity of sports-related concussion (Edwards & Bodle, 2014; Hanson et al., 2014; Harmon et al., 2013).

Asken and colleages (2016) and Harmon and colleagues (2013) note that the rate of undiagnosed concussions can be as high at 50%. The primary reason for concussions going undiagnosed is the underreporting, or misreporting, of concussion-related symptoms (Asken et al., 2016; Khurana & Kaye, 2012; Kimbler et al., 2011; Meier et al., 2015). Primary reasons for this misreporting include the likelihood that athletes may avoid reporting due to internal or external pressures to perform, many individuals may not think that their symptoms are severe enough to report, and it is common that athletes do not remember a specific instance where they would have sustained this injury (Delaney et al., 2015; Kimbler et al., 2011). Depending on the level of competition and setting there may also be adverse consequences for some players and teams if certain athletes are unable to continue play (Khurana & Kaye, 2012).

Asken and colleagues (2016) call for the investigation and determination of factors that can be identified and controlled in preventing concussion. As previously mentioned, risk factors for sports-related concussion include history of concussion, number, severity, and duration of symptoms, preinjury mood disorders, learning disorders, ADHD diagnosis, and competition level or setting of play (Harmon et al., 2013; Khurana & Kaye, 2012). It has also been noted that position played, playing style, and weak neck musculature are risk factors as well (Hanson et al., 2014; Harmon et al., 2013). Research points to some individual-level factors as possible risk determinants and markers of increased susceptibility to head injury including playing style or personality in competition, internal pressures and drives towards performance and achievement, and pre-existing disorders or diagnoses. These individual-level factors that may contribute to concussion originally, may also contribute to the likelihood of premature return to play and the possibility of acquiring multiple head injuries (Edwards & Bodle, 2014; Hanson et al., 2014; Harmon et al., 2013; Khurana & Kaye, 2012; Kimbler et al., 2011). The identification of these individual-level factors and indicators, especially with regards to personality, may help prevent the incidence and prevalence of repeat sports-related concussions through the ability to generate a profile of individuals that may be most at risk for these injuries.

Personality and Health Risk Behaviors

Sensation seeking is a personality construct that is defined by the tendency to seek novel or stimulating experiences and the willingness to take risks for these experiences (Zuckerman, 2008). The construct of sensation seeking is often conceptualized as including two related constructs: risk seeking and experience seeking (Conner, 2020). Risk seeking, or the inclination to take risks for the sake of experiences, and experience seeking, or the inclination to engage in novel and stimulating experiences, are related to engagement in health risk behaviors including substance use (Wagner, 2001), extreme sport participation (Bouter et al., 1988), risky sexual behaviors (Donohew et al., 2000), as well as criminal behavior (Horvath & Zuckerman, 1993). There is evidence to suggest that following repeated engagement in health risk behaviors, those high in sensation seeking would find these behaviors less novel, engaging, and stimulating and would therefore participate with less frequency (Cyders et al., 2009; Smith et al., 2007), although this trend differs by health risk behavior (Dick et al., 2010). There is consensus that while sensation seeking predicts engagement in health risk behaviors, other constructs, like sub-constructs of impulsivity, better predict the likelihood of problematic participation and frequency (Belin et al., 2008; Cyders et al., 2009; Dick et al., 2010; Smith et al., 2007).

Impulsivity is a broad concept that has been used in a wide range of personality models, risk models, as diagnostic criteria for many disorders and psychopathologies, and has been used to explain a diverse set of behaviors and outcomes (Cyders et al., 2007; Whiteside & Lynam, 2001). Most widely, impulsivity is defined as the tendency to act in a rapid, unplanned manner, with more consideration for immediate reward than long-term consequences for the self or others (Moeller et al., 2001; Whiteside & Lynam, 2001). Often included in discussions of impulsive behavior are terms such as sensation seeking, risk seeking, adventure seeking, and acting without thinking (Cyders et al., 2007). Cyders and colleagues discuss the likelihood that these are all diverse constructs with differing implications for health risk behaviors. As a result, impulsivity is often measured through sub-constructs that are either determined by more affective or more cognitive processes (Dick et al., 2010).

Impulsivity is often assessed through two methods: self-report questionnaires and laboratory-based behavioral measures (Dick et al., 2010). A widely used self-report questionnaire for impulsivity is the Barratt Impulsiveness Scale (BIS-11; Patton, Stanford, & Barratt, 1995). This scale assesses impulsivity across various dimensions including the first order factors of attention, motor, self-control, cognitive complexity, perseverance, and cognitive instability impulsiveness as well as the second order factors of attentional, motor, and non-planning impulsiveness (Patton et al., 1995; Stanford et al., 2009). Self-report measures of impulsivity, including the BIS-11, while highly correlated with one another, have shown only modest relations with behavioral measures of impulsivity (Dougherty et al., 2005; Reynolds et al., 2006). These behavioral measures, which target cognitive processes that underly impulsivity, have the advantage of being objective, performance-based measures. Behavioral measures may capture components of the multi-faceted construct of impulsivity that are not captured by self-report measures, including temporal state-dependent fluctuations in impulsive behavior (Dick et al., 2010; Dougherty et al., 2005; Reynolds et al., 2006). Reynolds and colleagues (2006) reported that, even among behavioral measures, outcomes vary widely, suggesting that behavioral tasks can differentially measure components of impulsivity.

In the same way that impulsivity is a heterogenous construct representing a wide range of behaviors, this personality dimension shows varied implications for health risk behaviors.

Impulsivity is predictive of substance use (Carlson et al., 2010; Robbins & Bryan, 2004), gambling (Chambers & Potenza, 2003), risky sport participation (Castanier et al., 2010; Thomson & Carlson, 2014), and risky sexual behaviors (Deckman & DeWall, 2011). There exists inconsistency in research conceptualization and findings about the relation and overlap of sensation seeking and impulsivity constructs. Often, sensation seeking is described as a sub-construct of impulsivity (Whiteside & Lynam, 2001). However, these two constructs display different developmental trajectories, complex and distinguishable behavioral components, as well as differential cortical and neural underpinnings (Steinberg, 2008; Steinberg et al., 2008). Cyders and colleagues (2007) mention the likelihood that there exist individuals who seek thrill and heightened sensation, like pilots, who make plans before risk-taking. For these reasons this study will assess sensation seeking and impulsivity as separate constructs.

Health risk behaviors have also been associated with additional personality dimensions, namely the Big Five personality traits. This Five-Factor model includes the personality constructs of extraversion, the tendency to enjoy social engagement and stimulation; agreeableness, the inclination towards care for others and awareness of others' emotions; conscientiousness, the propensity to be goal-focused and driven towards achievement; neuroticism, the tendency to experience negative emotion; and openness to experience, the tendency to be accepting and enjoy new experiences (Zuckerman et al., 1993). The Big Five personality traits have been proven to differentially predict health risk behavior outcomes. Generally, those participating in risky activities, especially risky sports, are low in the neuroticism dimension (Beidler et al., 2017b; Nicholson et al., 2005; Tok, 2011). It has also been shown that these individuals tend to be low in the conscientiousness dimension as well (Nicholson et al., 2005; Tok, 2011; Vollrath et al., 2003). Individuals with low conscientiousness and high extraversion and openness have also been found to engage in more risky behaviors outside of risky sport (Nicholson et al., 2005; Vollrath & Torgerson, 2002).

It has been established that sensation seeking, impulsivity, and the Big Five factors of personality all uniquely contribute to the incidence and prevalence of health risk behaviors (Bouter et al., 1988; Carlson et al., 2010; Castanier et al., 2010; Chambers & Potenza, 2003; Deckman & DeWall, 2011; Donohew et al., 2000; Horvath & Zuckerman, 1993; Nicholson et al., 2005; Robbins & Bryan, 2004; Thomson & Carlson, 2014; Tok, 2011; Wagner, 2001). Further research is needed regarding the degree to which these constructs differentially predict engagement in separate health risk behaviors. Additionally, further work is needed to investigate the degree to which sensation seeking may predict initial engagement in a risky activity, like a risky sport, while also investigating the extent to which impulsivity may better predict harmful and problematic participation once already involved in this activity.

Personality and Engagement in Risky Sports

Sensation seeking differentially predicts risky sport participation, and therefore injury risk, such that those who have higher levels of the sensation seeking personality trait sustain fewer injuries than those low in sensation seeking when participating in highly skilled, high-risk sports such as skiing and snowboarding (Bouter et al., 1988; Cherpitel et al., 1998; Turner et al., 2004). Additionally, perception of oneself as possessing a high level of skill in a risky sport has been shown to lead to a two times greater likelihood of also categorizing oneself as a risk taker (Paquette et al., 2016; Ruedl et al., 2010). This is consistent with previous findings regarding other health risk behaviors in which sensation seeking predicts engagement, but not necessarily problematic or harmful frequent engagement (Belin et al., 2008; Cyders et al., 2009; Dick et al., 2010; Smith et al., 2007). There is also evidence that those high in sensation seeking are involved in more risky sports than those low in sensation seeking (Diehm & Armatas, 2004), although those low in sensation seeking remain involved in the sport longer than those high in sensation seeking (Rowland et al., 1986; Jack & Ronan, 1988).

The sensation seeking personality construct has also been shown to predict spinal cord injuries (Mawson et al., 1988; Mawson et al., 1996) and concussion (Dretsch et al., 2017; O'Jile et al., 2004). Spinal cord injuries were predicted by high levels of sensation seeking, even when controlling for other factors usually associated with high sensation seeking personalities, like incidence of criminal behavior prior to spinal cord injury (Mawson et al., 1996). Concussions and spinal cord injuries associated with sensation seeking have been shown in sports-related contexts such as hockey (Osborn et al., 2009) as well as in the context of motor vehicle accidents. Turner and McClure (2004) found that high levels of risk acceptance predicted an eight times higher likelihood of sustaining a severe injury from a motor vehicle crash than those with lower acceptance of risk. This possibly suggests that individuals high in risk acceptance take more risks while on the road and experience more serious motor vehicle accidents. Paquette and colleagues (2016) also found that individual risk-taking behavioral tendencies predicted severity of injury. In their study involving alpine skiers and snowboarders, severity of injury was significantly positively related to risk-taking behavior. This association remained present even after controlling for personality characteristics, suggesting that protective behavioral strategies targeting modified risk-taking may be effective in lowering the rate of sustaining severe injury from extreme sports. It is also notable that in this study, injury seemed to act as a motivator in these sports, with participants reporting feeling a sense of belonging and comradery once they had sustained a sports-related injury. This suggests a sports-specific effect of returning to activity following injury, as well as a personality influence on what sports an individual chooses to participate in and the way one may view the effects and outcomes of injury. Because of the increased rate of injuries in more extreme sports like skiing and snowboarding, Thomson and colleagues (2012) created a sensation seeking scale, the Contextual Sensation Seeking Questionnaire for skiing and snowboarding, specifically for these sports to work towards injury prevention.

Sensation seeking has also been linked to established sports-related concussion risk factors like heading the ball in soccer (Webbe & Ochs, 2007) and history of concussion (Beidler et al., 2017a). In a sample of male soccer players, although results did not reach significance, it was found that those reporting the highest levels of sensation seeking via self-report methods were also the same individuals that reported moderate to high heading frequency (Webbe & Ochs, 2007). Further, in a sample of collegiate athletes, Beidler and colleages (2017a) found that those who reported two or more sports-related concussions were significantly higher in sensation seeking than those who reported a history of no sports-related concussions. Relatedly, the same study found that impulsivity was positively predictive of sports-related concussion such that those who reported two or more concussions also had significantly higher scores on the BIS-11 than those reporting one sports-related concussion and those reporting no sports-related concussions.

Findings for the relation between the Big Five factors of personality and sports-related injury are mixed, often depending on age group, sport played, personality construct, and whether engagement in sport or likelihood of injury is assessed. Although these findings vary, self-efficacy, or one's own belief in ability to succeed and complete a task, often mediates the effects of personality traits on risk-taking behavior in sport (Merritt & Tharp, 2013; Schwebel &

Plumert, 1999). Low conscientiousness is associated with risk-taking behavior and subsequent injury risk in scuba divers (Lee & Tseng, 2015; Tok, 2011), free runners (Merritt & Tharp, 2013), and accident-prone children (Vollrath et al., 2003), while it is predictive of risky sport engagement in free diving, paragliding, rafting, rock climbing, and surfing (Castanier et al., 2010; Tok, 2011). Conscientiousness has also been found to be associated with greater likelihood of adhering to treatment and return to play protocol (Beidler et al., 2017b), and may be associated with greater likelihood of sustaining a severe injury at low levels (Tok, 2011). High levels of openness to experience and extraversion (Diehm & Armatas, 2004; Schwebel & Plumert, 1999) have been associated with tendency towards risk-taking behavior (Lee & Tseng, 2015) as well as engagement in risky sports (Castanier et al., 2010; Tok, 2011). Additionally, extraversion has been shown to be positively and significantly predictive of frequency of heading the ball in soccer, an established risk factor of sports-related concussion (Webbe & Ochs, 2007). Findings for neuroticism are mixed, with high levels of neuroticism being associated with risk taking behavior in white water rafting and scuba diving (Merritt & Tharp, 2013), no relationship between neuroticism and accidental injury in accident-prone children (Vollrath et al., 2003), and low levels of neuroticism associated with those partaking in sports with a high risk of sports-related concussion (Beidler et al., 2017b). Personality factors are also significantly associated with symptom reporting. Low agreeableness (Beidler et al., 2017b; Merritt et al., 2015) and low neuroticism (Merritt et al., 2015) have been found in those that fail to report previous concussions or concussion symptoms, although those high in agreeableness tend to report less symptoms at baseline and post-injury.

Overall, research utilizing psychological factors as predictors of sports-related concussion outcomes is limited, specifically research utilizing personality as a predictor (Trinh et al., 2019).

A recent systematic review published by Trinh and colleagues highlights this gap in the literature with the inclusion of just 10 studies that investigated psychological factors, including the Big Five factors of personality, emotional state, temperament, life stressors, and explanatory style, as predictors of sports-related concussion outcomes. It was found that individuals with higher levels of irritability, sadness, and nervousness at baseline were at increased risk of high symptom scores and an increased risk of developing a psychiatric illness post-injury. Further, lower levels of harm avoidance including excessive worrying, pessimism, shyness, and being fearful, were associated with higher incidence of concussion. With regards to life stressors, more pre-injury life stressors like bullying or loss of a loved one were associated with greater symptoms post-concussion. Explanatory style was found to be largely unrelated to sports-related concussion incidence however, optimists were found to have longer recovery time post-injury. This review included just 3 studies with a focus the Big Five as predictors. These studies concluded that extraversion is positively predictive of frequency of heading the ball in soccer, agreeableness is significantly associated with lower reports of undiagnosed concussion and post-concussive symptoms, and neuroticism is significantly and positively associated with more post-concussive symptoms.

The review conducted by Trinh and colleagues (2019), as well as the study conducted by Beidler and colleagues (2019a) that found a positive association between sensation seeking and impulsivity with history of sports-related concussion, show the significant relations that exist between the personality factors of interest in the present study and sports-related concussion risk factors and related outcomes. Further, this recently published systematic review highlights the paucity of studies examining these relations of interest in the present study. The review calls for more research in this area to better examine these relations, as well as more investigation into specific relations between a variety of personality factors and additional sports-related concussion outcomes. The aim of such studies would be to better understand how personality may be used in the prevention of sports-related concussion.

While there is established evidence that sensation seeking is related to risky behavior, and that risky behaviors, such as excessive alcohol consumption, can lead to an increased incidence of head injury, there is little research on premorbid characteristics in adults that may increase likelihood of head injury or concussion (O'Jile et al., 2004). Further, there has been research conducted on the effect that pre-injury personality characteristics have on post-injury recovery, symptom lingering, symptom reporting, and depression, but not as much on how personality may impact risk-taking behaviors and premature return to play (Merritt et al., 2015; Rush et al., 2004; Shapcott et al., 2007; Yuen et al., 2016). Additionally, there is a growing body of literature regarding personality change following concussion, primarily regarding impulsivity (Kocka & Gagnon, 2014; Rochat et al., 2010; Votruba et al., 2008). For the purposes of this study, the focus will be on existing personality traits, regardless of if these characteristics are premorbid or due to a previous injury, and how these traits may impact health risk behavior engagement, particularly return to play in sports and activities and subsequent concussion risk.

Protective Behavioral Strategies

Protective behavioral strategies, or behaviors and cognitive-behavioral strategies that reduce negative consequences surrounding substance use, have been a growing area of research with regards to alcohol use, and most recently marijuana use (Martens et al., 2005; Pearson, 2013; Pedersen et al., 2016). Research prior to this concept focused on individual level factors that could be targeted to help in intervention and prevention of negative consequences surrounding substance use; however, researchers saw the need to target a component of substance use harm reduction that could be learned or taught (Martens et al., 2005). Although there is some variability in operationalization, all protective behavioral strategies can be learned, taught, and used as strategies to aid in prevention and intervention for alcohol and marijuana-related consequences. Most researchers have concluded that the definition of protective behavioral strategies that targets behaviors during substance use is the most effective and easiest to measure in a self-report format, but more global strategies are often utilized that include behaviors before consumption, after the period of substance use, cessation of substance use altogether, safety plan strategies, and avoidance of social consequences (Pearson, 2013; Prince et al., 2013).

In a review paper, Pearson (2013) states that every study in the review included results that support the notion that when more protective behavioral strategies are used, individuals report drinking less and having less alcohol-related consequences. Similarly, Pedersen and colleagues (2016) report similar findings with protective behavioral strategies, marijuana use, and marijuana-related consequences. To measure this concept, the Protective Behavioral Strategies Scale (PBSS) (Martens et al., 2005) and the Protective Behavioral Strategies for Marijuana (PBSM) scale (Pedersen et al., 2016) were created. Pearson (2013) reports that measures of protective behavioral strategies in which individuals respond using contingent frequency response scales, or scales ranging from “Always” to “Never”, have resulted in the highest concurrent validity. While this is a valuable area of research in substance use, similar protective behavioral strategies are also used practically in sports injury prevention as well. To date there are no protective behavioral strategy scales or injury harm reduction scales to be used to measure this concept in sport, but research has shown a great deal of growth in the investigation of helmet use in sports, concussion protocol, return to play protocol, rule changes in concussion-prone sport, and individual level protective behavioral strategies to aid in injury reduction, specifically concussion reduction, among athletes.

Protective equipment such as helmets, mouth guards, and facial protection, both hard and soft, have shown inconsistent results in prevention of concussion. Overall, helmets and mouthguards have been proven to prevent death and severe injury such as skull fractures, severe traumatic brain injury, oral and jaw injuries, scalp lacerations, etc. but have not been shown to significantly reduce the incidence or severity of concussion in sport (Benson et al., 2013; Daneshvar et al., 2011; Hanson et al., 2014; Harmon et al., 2013; Schneider et al., 2017; Stuart et al., 2002). More specifically, the extent to which helmets are protective can vary by sport. Helmets are known to significantly reduce concussion in skiing, snowboarding, and cycling (Daneshvar et al., 2011; Emery et al., 2017; Hagel & Meeuwisse, 2004; Ruedl et al., 2010; Spaite et al., 1991; Thomson & Carlson, 2015). Spaite and colleagues (1991) found that those cycling and not wearing helmets were seven times more likely to sustain a major or severe injury following a motor vehicle accident than those who were wearing helmets, indicating a significant protective effect of helmet use. There have been efforts to modify equipment with the goal of reducing the rate of concussion. As reducing the severity of impact is the most prominent goal in concussion prevention, helmets have seen modifications over time to enhance the ability to reduce acceleration of the head and to absorb more of the force on impact (Benson et al., 2013; Daneshvar et al., 2011). There also exists a movement to change the standard baseball to a model with less mass and stiffness (Daneshvar et al., 2011). This baseball has not been studied in relation to concussions, but has been proven to reduce risk of injury, including severe traumatic brain injury by 28%.

Although the improvement of protective equipment is a useful strategy for concussion prevention, other strategies for concussion prevention include player and coach education regarding concussion signs, symptoms, and return to play, rule changes, rule enforcement, "collision anticipation" training, neck and shoulder strengthening, and legislation regarding return to play (Danseshvar et al., 2011; Hanson et al., 2014; Harmon et al., 2013). Specifically, enforcing fair play rules and eliminating body checking in youth hockey has proven effective in concussion reduction (Benson et al., 2013; Emery et al., 2017). Evidence for increased neck strength has been mixed (Benson et al., 2013), but this factor contributes to increased physical fitness, which has been shown to often correlate with reduced concussion as a result of increased size, speed, and ability to anticipate collision (Abrahams et al., 2014). Further, as level of competition is a major risk factor in concussion, it has been suggested to minimize contact play in practices to reduce overall exposure to contact; however, this strategy may not be as effective as desired due to there being a 26 times greater likelihood of sustaining a concussion in match play as opposed to practice play (Abrahams et al., 2014; Noble & Hesdorffer, 2013). According to the 2017 Berlin Concussion in Sport Group Consensus Statement in Contact and Collision Sports, if an athlete sustains a concussion, they may not return to play that same day (Patricios et al., 2018). Additionally, return to play after concussion diagnosis can only occur if concussion-related symptom scores, both at rest and competition-level exercise, have returned to baseline, if neuropsychological testing and balance testing have returned to baseline, and if cognitive testing returned to baseline. However, many of these measures have variable test-retest reliability for a variety of reasons, including athletes underperforming on baseline measures, often referred to as sandbagging, to make it easier to attain the same score post-concussion (Higgins et al., 2017). Typically, the gradual return to play protocol lasts around 7 days. Follow-up evaluations should also be conducted, regardless of initial concussion diagnosis. Adherence to this protocol is a significant harm reduction and protective measure in concussion recovery and prevention.

Factors Affecting Protective Behavioral Strategies

Risk homeostasis, or risk compensation, is seen as a possible risk of an increase in mandated helmet use. It is proposed that the use of protective gear can lead to a false sense of security for an individual or may lead them to believe they are at a decreased level of risk and must increase risky behavior while participating in sport to attain their optimal level of stimulation once again (Daneshvar et al., 2011; Hagel & Meeuwisse, 2004; Thomson & Carlson, 2015). Thomson and Carlson (2015) found that both sensation seeking and helmet use were predictive of greater risk-taking behavior in skiing and snowboarding, indicating a possible effect of personality in those that may partake in risk compensation. The concept of risk compensation has shown mixed findings in research, with helmet use showing a negative relationship with risky behavior in cycling and skiing (Radun et al., 2018; Ruedl et al., 2010). One study found that sensation seeking is a greater predictor of risky behavior while skiing and snowboarding than helmet use, but that self-reported risk compensation while wearing a helmet increases with age, skill level, and skiing time (Ruedl et al., 2012). While findings are mixed, they suggest that personality may play a role in harm reduction strategies used, but also behavior as a result of using a harm reduction strategy, like the use of a helmet. Further, studies have shown that a tendency toward aggressive behavior is a risk factor for concussion and a possible mediator in the relation between protective strategies and concussion (Abrahams et al., 2014). The relationship between personality and protective behaviors in sport is also closely tied to symptom reporting. Without accurate symptom reporting, proper safety precautions and protocols will not be followed. As previously stated, low agreeableness (Beidler et al., 2017b;

Merritt, et al., 2015) and low neuroticism (Merritt et al., 2015) have been found in those that fail to report previous concussions or concussion symptoms. In one study, it was found that individuals who were pressured by parents, coaches, teammates, and fans to keep playing following a head impact during a college athletic event were significantly more likely to intend to continue playing and avoid symptom reporting following a subsequent concussion-related impact (Kroshus et al., 2015). 25% of these athletes had experienced pressure to keep playing following impact in the past year. This research further displays that protective behaviors and actions taken can result from internal or external pressures and influences, and personality likely plays a role in actions taken as a result of these pressures.

With more knowledge regarding effective and commonly used harm reduction strategies for concussion, more unique and tailored safety protocols may be created for specific sports and activities, with consideration for individual level factors that may place an athlete at increased or decreased risk of concussion during sport. Further, knowledge regarding factors and traits of individuals least likely to use these strategies may help in targeting those in most need of safety suggestions and protocol monitoring throughout the course of recovery.

Current Study

The roles of sensation seeking, impulsivity, and the Big Five factors of personality have been investigated as they relate to engagement in risky behavior in sport in general, but not in relation to continued risky behavior following concussion, particularly with regard to the decision to re-engage in sport following a particular time period and adherence to harm reduction safety measures. Further, personality findings for risk-taking behavior in sport and subsequent injury are mixed, possibly due to the paucity of studies investigating specific sub-factors of personality constructs (sensation seeking and impulsivity) and how these sub-factors may impact sport injury outcomes. Additionally, few studies have investigated the behavioral (state) and self-report (trait) dimensions of impulsivity in the same study, with none focusing on repeat engagement in sport (Reynolds et al., 2007; Yeomans et al., 2008).

Hypotheses

Hypothesis 1: I predicted that sensation seeking, impulsivity, and the Big Five factors of personality would differentially predict time to re-engagement in the same sport following a sports-related concussion.

Hypothesis 1a: I predicted that sensation seeking, impulsivity, extraversion, and openness to experience would be negatively and significantly associated with time to return to play, such that those who are higher in these personality constructs would take less time to return to play than those who are lower in these personality constructs holding constant injury severity.

Hypothesis 1b: I predicted that neuroticism, conscientiousness, and agreeableness would be positively and significantly associated with time to return to play, such that those who are higher in these personality constructs would take more time to return to play than those who are lower in these personality constructs holding constant injury severity.

Hypothesis 2: I predicted that sensation seeking, impulsivity, and the Big Five factors of personality would differentially predict likelihood of subsequent injury following a sports-related concussion.

Hypothesis 2a: I predicted that impulsivity, extraversion, and openness to experience would be positively and significantly associated with likelihood of subsequent concussion, such that those higher in these personality constructs will be more likely to sustain subsequent concussions following an initial concussion than those lower in these personality constructs holding constant injury severity.

Hypothesis 2b: I predicted that sensation seeking, neuroticism, conscientiousness, and agreeableness would be negatively and significantly associated with likelihood of subsequent concussion, such those higher in these personality constructs would be less likely to sustain subsequent concussion following an initial concussion than those lower in these personality constructs holding constant injury severity.

Hypothesis 3: I predicted that sensation seeking, impulsivity, and the Big Five factors of personality would differentially predict protective behavioral strategy use following a sports-related concussion.

Hypothesis 3a: I predicted that sensation seeking, neuroticism, conscientiousness, and agreeableness would be positively and significantly associated with likelihood of protective behavioral strategy use, such that those higher in these personality constructs would be more likely to use protective behavioral strategies than those lower in these constructs holding constant injury severity.

Hypothesis 3b: I predicted that sensation seeking and impulsivity would be negatively and significantly associated with overall protective behavioral strategy use, such that those high in these personality constructs would use less protective behavioral strategies than those lower in these constructs holding constant injury severity.

Hypothesis 3c: I predicted that neuroticism, conscientiousness, and agreeableness would be positively and significantly associated with overall protective behavioral strategy use, such that those high in these personality constructs would use more protective behavioral strategies than those lower in these constructs holding constant injury severity.

Testing these hypotheses contributes to literature and efforts to differentiate the effects of personality dimensions on risk-taking behavior in sport, which allows for improved protective behavioral strategies. Highlighting individuals most at risk of concussion, as well as those most at risk for not taking proper safety precautions following concussion will help experts and professionals target those most in need of protective strategies and modified participation.

CHAPTER 2: METHOD

Participants and Procedures

Participants were undergraduate female and male students (*M*$_{age}$ = 19.47, *SD* = 2.14, female = 64.5%) recruited from introductory psychology and research methods courses between March 2019 and December 2019 (N = 1141). All demographic information is included in Table 1. Introductory psychology students represent a variety of academic majors, and all participants received course credit for their participation. This study was part of a larger online study investigating personality and health risk behaviors. Participants were given the option to consent online before beginning the survey and were instructed that they could discontinue participation at any time without penalty, as well as skip any questions they did not wish to answer. Participants were also informed of the confidential nature of the survey; for example, participants were informed that survey answers would not be shared with coaches, athletic trainers, etc. Following participation, individuals were given written debriefing information that included contact information for counseling services.

The study was conducted in a lab space via an online platform utilizing laptops set up in private workspaces. Participation was monitored by a trained research assistant. Participants first completed the GoStop Paradigm following the instruction of a research assistant (~11 minutes). Next, the participants were given instructions for the Time Paradigm before completion of the task (~5 minutes). Following completion of these tasks, participants completed the survey portion of the study (~20-45 minutes). All participants were given a random participant ID number upon entrance into the lab. The ID number was utilized to link GoStop Paradigm, Time Paradigm, and survey data, with no document kept to link participant name and ID number.

Table 1: Self-Reported Participant Demographics

	N	%
Sex		
Female	729	64.2
Male	407	35.8
Not Specified	5	-
Gender		
Woman	720	63.4
Man	406	35.7
Non-binary/Non-conforming	9	0.8
Another Identity	1	0.1
Not specified	2	-
Race		
American Indian	35	3.0
Asian	69	5.9
African American	57	4.9
Hawaiian/ Pacific Islander	11	0.9
White	996	85.3
Not Specified	55	-
Ethnicity		
Hispanic or Latino	215	19.3
Not Hispanic or Latino	897	80.7
Not Specified	29	-

Measures

Personality Dimensions

Sensation seeking was assessed using the Sensation Seeking Personality Type scale (SSPT; Conner, 2020). This scale assesses two dimensions of sensation seeking: experience seeking (Cronbach's $\alpha = 0.70$), or an individual's tendency to seek out novel or stimulating experiences, and risk seeking (Cronbach's $\alpha = 0.86$), or an individual's tendency to take risks including legal, social, physical, and psychological risks. Each dimension contains 5 items, each assessed with a five-point Likert scale ranging from "strongly disagree" to "strongly agree". Experience seeking items include items such as: "I don't enjoy trying new things" and "I love challenging myself with new and interesting tasks". Risk seeking items include items such as: "I have the most fun when I am doing risky or dangerous things", and "I rarely do things that seem risky". Experience seeking (M = 19.96, SD = 2.68) and risk seeking variables (M = 13.83, SD = 3.91) were both continuous and normally distributed in this sample.

Self-report impulsivity was assessed using the most widely used self-report questionnaire for impulsivity to date, the Barratt Impulsivity Scale (BIS-11; Patton et al., 1995). This scale measures impulsivity across various dimensions including the first order factors of attention, cognitive instability, motor, perseverance, self-control, and cognitive complexity as well as the second order factors of attentional, motor, and non-planning impulsiveness (Patton et al., 1995; Stanford et al., 2009). This measure consists of 30 items describing impulsive or non-impulsive behaviors or preferences; individuals answer using a 4-point Likert scale ranging from "rarely/never" to "almost always/always". This measure includes items such as: "I save regularly", "I am restless at the theater or lectures", and "I say things without thinking". The use and interpretation of statistical analyses using first order factors, second order factors, and an impulsivity total score are all supported (Patton et al., 1995; Stanford et al., 2009). For this reason as well as for the purpose of parsimony and interpretability, analyses in the current study were conducted using second order factors, attentional impulsivity ($M = 17.92$, $SD = 4.01$, $\alpha = .72$), motor impulsivity ($M = 22.47$, $SD = 4.09$, $\alpha = .67$), and non-planning impulsivity ($M = 24.4$, $SD = 4.58$, $\alpha = .62$). Internal consistency values for these variables are acceptable in this sample. The impulsivity variables used for analyses in this study were all continuous and normally distributed.

Behavioral impulsivity was assessed using the Laboratory Behavioral Measures of Impulsivity– Impulsivity Bundle paradigms (Dougherty et al., 2005). The four tasks included are the Two-Choice Impulsivity Paradigm, the Single Key Impulsivity Paradigm, the GoStop Impulsivity Paradigm, and the Time Paradigm, although the GoStop Paradigm and the Time Paradigm were the only tasks utilized in this study. The GoStop Impulsivity Paradigm is a response disinhibition task to assess ability to inhibit an already initiated response. In this task, numbers are presented in black text on the screen; if each number is the same as the last, the individual is instructed to respond, as this is the “go” signal. If each number is different than the one before it, the participant is not to respond. In the experimental trials, an identical black number is presented, signaling the “go” response, but the number turns red at a predetermined time interval after the “go” response is initiated; this red number is the “stop” signal. More impulsive individuals would have a more difficult time stopping their response after it has already been initiated by the “go” signal. This variable, referred to as “percent inhibited”, was captured via the percent of “stop” trials where the prepotent response was successfully inhibited ($M = 39.83\%$, $SD = 27.28$). Lastly, the Time Paradigm assesses time perception. Impulsive individuals are more likely to have a skewed perception of time due to feeling that time is moving more slowly. In this task, individuals are given a pre-selected interval of time for which they must start a hidden timer and stop the timer after they believe the interval of time has passed. Participants were given a 60-second interval of time and asked to hold down a button until they believed that time had elapsed. Individuals were allowed to look at past performance and adjust based on feedback. The amount of time spent looking at feedback was recorded as well. The time estimation of all five trials was averaged into one “mean time estimation” variable (M = 56.24 seconds, SD = 8.13). Correlations between behavioral and self-report impulsivity measures are included in Table 2. In general, correlations between self-report and behavioral impulsivity in this sample were slightly weaker than expected. Estimates from the Time Paradigm, like mean time estimation, tend to have a correlation of -.01 with self-report measures of impulsivity. Motor impulsivity has been found to have a correlation of .06 with go/no-go tasks. Overall, behavioral and self-report measures are found to have a correlation of .097.

Table 2: Correlations Between Self-Report and Behavioral Impulsivity

	Go Stop 350ms Inhibition	Mean Time Estimation
Non-planning Impulsivity	.03	-.05
Attentional Impulsivity	-.03	-.05
Motor Impulsivity	.02	-.04

The Big Five personality traits of Extraversion (M = 8.88, SD = 3.06), Agreeableness (M = 9.77, SD = 2.10), Conscientiousness (M = 10.61, SD = 2.41), Neuroticism (M = 8.82, SD = 2.91), and Openness to Experience (M = 10.94, SD = 1.99) were assessed using the Ten Item Personality Inventory (TIPI; Gosling et al., 2003). All 5 variables were continuous and normally distributed in this sample. This ten-item questionnaire includes five, two-item pairs of statements that each correspond to one Big Five personality trait. Individuals respond using a 7-point Likert scale ranging from “disagree strongly” to “agree strongly”. The questionnaire asks individuals to respond regarding to what extent they identify themselves as possessing certain characteristics (careless, enthusiastic, etc.). Because this scale includes two-item measures of individual constructs, test-retest reliability is reported as opposed to internal consistency reliability (mean r = .80).

Protective Behavioral Strategies

These 22 items ask individuals to respond on a 7-point Likert scale ranging from “never” to “always” regarding their current or past participation in each protective strategy, with the option to select “N/A” if the strategy does not apply. These items target 4 types of harm reduction behavior: injury prevention, strategies used while playing or participating, post-injury recovery safety measures, and complete cessation of the behavior or activity. Examples of each item category are below.

Preventative: “I avoid/avoided situations where others would be participating in risky physical activities”

During Participation: “I avoid/avoided contact while participating”

Post-injury/Recovery: “I participate/participated in cognitive rest to reduce symptoms”

Cessation: “I stopped participating in the activity following my injury”

Distributions among the 22 protective behavioral strategy items varied widely. Some of the items followed a normal distribution (e.g. Item 8: “I take time off before participating again”), some followed a count distribution with most people indicating that they “almost always” or “always” use the strategy following concussion (e.g. Item 21: “I follow all of the doctor’s instructions for recovery”), some followed a count distribution with most people indicating that they “never” or “rarely” use the strategy (i.e. Item 13: “I change who I participate with”), and some followed a fairly platykurtic distribution where participants indicated nearly

Table 3: Frequency of Protective Behavioral Strategy Use

Item	Never	Almost Never	Rarely	About half the time	Most of the time	Almost Always	Always
1	163 (18.1)	109 (12.1)	222 (24.6)	155 (17.2)	109 (12.1)	73 (8.1)	71 (7.9)
2	113 (12.4)	109 (12)	193 (21.2)	176 (19.3)	161 (7.0)	94 (10.3)	64 (7.0)
3	60 (6.6)	65 (7.1)	144 (15.8)	115 (12.6)	199 (21.9)	158 (17.4)	169 (18.6)
4	147 (16.6)	125 (14.1)	223 (25.1)	146 (16.4)	135 (15.2)	72 (8.1)	40 (4.5)
5	145 (16.2)	134 (15)	191 (21.4)	131 (14.7)	139 (15.5)	93 (10.4)	61 (6.8)
6	169 (18.8)	158 (17.6)	191 (21.3)	137 (15.3)	129 (14.4)	72 (8.0)	42 (4.7)
7	169 (18.8)	145 (16.1)	200 (22.3)	123 (13.7)	152 (16.9)	69 (7.7)	40 (4.5)
8	94 (10.5)	87 (9.7)	156 (17.4)	166 (18.6)	186 (20.8)	115 (12.9)	90 (10.1)
9	156 (17.2)	131 (14.5)	234 (25.9)	141 (15.6)	106 (11.7)	90 (9.9)	47 (5.2)
10	129 (14.3)	130 (14.4)	178 (19.7)	174 (19.3)	158 (17.5)	88 (9.7)	46 (5.1)
11	111 (12.6)	75 (8.5)	102 (11.6)	132 (15.0)	178 (20.3)	154 (17.5)	126 (14.4)
12	159 (18.9)	110 (13.1)	134 (16)	132 (15.7)	116 (13.8)	97 (11.5)	92 (11.0)
13	233 (26.6)	151 (17.2)	217 (24.8)	117 (13.4)	81 (9.2)	48 (5.5)	29 (3.3)
14	96 (10.7)	85 (9.5)	112 (12.5)	141 (15.8)	201 (22.5)	144 (16.1)	115 (12.9)
15	183 (20.8)	109 (12.4)	171 (19.4)	137 (15.6)	140 (15.9)	91 (10.3)	49 (5.6)
16	185 (21.6)	106 (12.4)	128 (14.9)	115 (13.4)	135 (15.7)	122 (14.2)	67 (7.8)
17	100 (11.4)	83 (9.4)	102 (11.6)	127 (14.4)	182 (20.7)	163 (18.5)	123 (14.0)
18	110 (12.7)	96 (11.1)	105 (12.2)	139 (16.1)	157 (18.2)	151 (17.5)	106 (12.3)
19	68 (7.8)	61 (7)	88 (10.1)	134 (15.3)	191 (21.8)	182 (20.8)	151 (17.3)
20	89 (10.3)	62 (7.2)	111 (12.9)	146 (16.9)	160 (18.5)	168 (19.5)	127 (14.6)
21	50 (6.0)	28 (3.4)	58 (7)	99 (12.0)	141 (17.0)	208 (25.2)	243 (29.4)
22	93 (10.7)	109 (12.5)	148 (17)	136 (15.6)	139 (15.9)	120 (13.8)	127 (14.6)

Note: Frequency (% Frequency)

Table 4: Protective Behavioral Strategy Use from Most Used to Least Used

Item 21: I follow all the doctor's instructions for recovery
Item 19: I participate in balance and strengthening exercises
Item 3: I wear protective gear
Item 20: I participate in sub-symptom exercise (non-risky cardio)
Item 14: I evaluate how I feel before I participate each time
Item 17: I continue to educate myself on concussion symptoms, signs, and protocol
Item 11: I establish a symptom limit at which I would stop playing and seek help
Item 18: I participate I cognitive rest to reduce symptoms
Item 8: I took time off before participating in the activity again
Item 22: I avoid participation when I am not feeling like my 'head is in the game'
Item 2: I avoid other physically risky activities
Item 12: I establish a number of hits or level of contact at which I would stop playing
Item 10: I take more breaks during participation
Item 16: I choose a friend to help me identify concussion-related symptoms while participating
Item 5: I avoid contact during participation in a sport or activity
Item 15: I find new friends outside the sport/create a support network outside the sport
Item 1: I stop participating in an activity
Item 9: I avoid social contexts where others may be participating in physically risky activities
Item 4: I participate in activities at a less competitive or intense level than before
Item 7: I participate for shorter amounts of time than before
Item 6: I participate less often than before
Item 13: I change who I participate with

equal frequency of use ranging from "never" to "always" (i.e. Item 22: I avoid participation when I feel like my 'head is not in the game'"). Taken as a whole, the protective strategy use total score was a continuous and normally distributed variable (M = 92.73, SD = 51.62). The total score was calculated with 1 point corresponding to an answer of "never" and 7 points corresponding to an answer of “always” for each item. For hypothesis 3, an additional binary outcome variable was created that divided participants into two groups, one group that captured protective strategy use at the 75th percentile or above, and another group that captured protective strategy use at the 50th percentile or below. The full scale can be found in Table A1 in the Appendix. Frequency of endorsement for each protective behavioral strategy is included in Table 3. A list of most used to least used protective behavioral strategies is included in Table 4.

Concussion Questions

Participants first received a question asking if they have ever sustained a sports-related concussion. If they answered yes, additional questions included those targeting severity of injury (“Was this injury diagnosed by a medical professional?”, “What was the worst symptom associated with this injury?”, “Did you seek immediate medical attention for this injury?”, “Did you lose consciousness as a result of this injury?”, “Are you currently experiencing any symptoms from this injury? If so, what are the symptoms?”) and details surrounding re-engagement in sport (“Did you participate in the same sport again following injury? If so, how long did it take you to participate again? Did you participate at full capacity? Were there modifications?”, “Did you participate in another sport following this injury? If so, how long after the injury did you start participating in this sport? What is the sport? How competitive is the sport? Had you participated in this sport before injury? If so, did you modify your participation after the injury?”). Further questions included a prompt to describe the incident in which the injury occurred, when (month, year) the injury occurred, what sport was being played, what position was being played (if applicable), description of coach or referee involvement, and a question regarding pressure felt to continue playing at the time of injury.

Most questions regarding concussions in this study were multiple choice, taking the form of either "yes/no" response options or Likert scale response options. Open response questions were limited and included those that asked the participant to describe the incident in which they were injured and also to describe steps taken immediately post injury by the participant themselves, as well as parents, coaches, and trainers. Further open response questions were those inquiring about pressure to continue playing, specifics about any medical instructions received, a list of symptoms experienced, what changes or modifications were made if the participant returned to play post-injury, and a list of sports that the participant took part in pre- and post-injury.

In the current sample, 352 participants (32%) indicated that they had experienced at least one sports-related concussion. Of these participants, 178 (51%) indicated that they had experienced one sports-related concussion, while 171 (49%) indicated that they had experienced two or more sports-related concussions. Further, of the sample that indicated that they had experienced at least one sports-related concussion, 148 (42%) answered that they had experienced at least one sports-related concussion that was not formally diagnosed by a trained medical professional, 126 (35.8%) indicated that they had not sustained an undiagnosed concussion, and 78 (22.2%) of participants indicated that they are not sure if they have experienced an undiagnosed concussion or not.

Time to return to play was assessed via a self-report question asking, "How long did it take you to return to play follow this concussion?" with the option for participants to indicate time in days, weeks, or months. Self-reported time to return to play was converted to weeks for analysis. This item was presented in reference to each concussion (first, most recent, most severe), but first concussion was used in analysis as this maximized both the number of participants who could be included in analysis and the amount of time that had passed that would allow for return to play. Almost everyone returned to play in the sample (313/336 = 93.2%). The mean number of weeks to return to play was 19.45 (SE = 2.84) weeks, while the median was 2 weeks.

Analysis

Prior to conducting hypothesis testing, missing data were analyzed to determine if there were systematic patterns of missingness. Little's Missing Completely at Random (MCAR) test was used to establish that there were no significant differences in the complete and missing data ($p = .051$). Multiple imputation was then conducted on the original dataset. This imputed dataset was used for analysis in hypotheses 2 and 3. The imputed dataset was not used for survival analysis or exploratory factor analysis. All analyses were conducted for sports-related concussion injuries that were sustained at age 12 or older.

After data were imputed, all personality variables to be included in each model were tested for multicollinearity. The variance inflation factors (VIF) for each personality variable in each case ranged from 1-2, indicating little inflation of regression coefficients as a result of correlation between predictor variables. Additionally, tolerance was such that the majority of variance in each personality variable could not be explained by other predictors in the model.

All analyses were conducted using the R version 3.5.3 (R Core Team, 2019). Survival analysis was used to assess the time to return to play following a sports-related concussion for those that re-engage in the same sport following injury (Hypothesis 1). This analysis included 2 parts: the first part included descriptive Kaplan Meier and logrank analysis and the second included Cox Proportional Hazards modeling, a form of multivariate regression analysis for investigating predictors of time to return to play. For both types of analysis the dependent variable remained the same. The dependent variable in survival analysis consists of 2 components: an event indicator and the length of time between baseline and event of interest occurrence for each individual. In this study, event = 1 indicated return to play at some point following a sports-related concussion and prior to completion of the survey. Subsequently, event = 0 indicated that an individual had not yet returned to play at the time the survey was completed. The second component of the dependent variable, time to event of interest, was defined as the number of weeks between sports-related concussion and return to play as reported by each participant. Individuals who had not returned to play by the time of the study (event = 0) were considered censored. The term censored implies that event = 0 is not the absence of the tendency or ability to return to play but does inform researchers that these individuals had not yet returned to play when the study was complete. This dependent variable, from here referred to as time to return to play, was a variable representing return to play following a single concussion, thus this variable is a single-event variable. No participants were able to indicate that they returned to play more than 1 time following this single injury.

For descriptive analysis, including Kaplan Meier and logrank analyses, all personality factors of interest were utilized as independent variables. For these analyses, personality variables were included as binary variables to assess for significant differences between personality groups. These personality variables were defined such that those possessing the trait at the 50th percentile or above were included in the "high" personality group, while those possessing the trait in the 49th percentile or below were included in the "low" personality group. These personality predictors were time-invariant predictors, indicating that these predictors were assumed to be constant over the time period of interest in this study. These predictors were assumed to be time-invariant as a result of the study design including a single report of personality measures, the nature of the relative stability of personality traits, and the relatively short amount of time on average between return to play and completion of the study. These variables are assumed to be constant between the time when the events of interest were occurring (concussion and return to play) and the time individuals were assessed for study completion. Table 5 includes information about the number of participants who fell into these groups for each personality factor.

Table 5: Personality Groups for Survival Analysis

	Low (< 50^{th} percentile)	**High (>= 50^{th} percentile)**
Risk Seeking	119/302 (39.4%)	183/302 (60.6%)
Experience Seeking	103/298 (34.6%)	195/298 (65.4%)
Attentional Impulsivity	135/304 (44.4%)	169/304 (55.6%)
Motor Impulsivity	121/305 (39.7%)	184/305 (60.3%)
Non-planning Impulsivity	129/307 (42%)	178/307 (58%)
Agreeableness	155/314 (49.4%)	159/314 (50.6%)
Extraversion	111/310 (35.8%)	199/310 (64.2%)
Conscientiousness	128/311 (41.2%)	183/311 (58.8%)
Openness to Experience	123/309 (39.8%)	186/309 (60.2%)
Neuroticism	133/310 (42.9%)	177/310 (57.1%)
Mean Time Estimation	154/312 (49.4%)	158/312 (50.6%)
Go Stop % Inhibited	139/311 (44.7%)	172/311 (55.3%)

Kaplan Meier analyses fit models of the effects of binary personality predictors on time to return to play such that probability of survival, or probability of not returning to play, is plotted for each group (high and low personality groups) and these groups are compared for significant differences in their survival curves. As a result, probability of return to play at given points in time was investigated at varying degrees of each personality construct. Subsequent logrank tests were conducted to determine the chi-square statistic for the difference between high and low personality groups in survival probability. Each personality predictor was investigated in a separate model to attain the independent effects of differing levels of each personality construct on probability of return to play. Chi square values and p-values were used to assess for significance of these results.

Before personality variables could be investigated as predictors of risk of return to play, assumptions were checked to determine an appropriate model for these analyses. Assumptions for Cox Proportional Hazards were met, including proportionality of hazards. Proportionality of hazards assumes that the hazard ratios, or the relative risk of return to play, is relatively constant for 2 groups being compared over time. This assumption was confirmed through Kaplan Meier plots and analysis. Cox Proportional Hazard Models were then utilized to analyze the continuous forms of the personality variables as predictors of survival probability. The continuous forms of these variables were also assumed to be time-invariant. First, individual models were run in which time to return to play was regressed on each personality variable in a separate model. These analyses were utilized to investigate independent predictive effects of each personality variable on time to return to play, as well as to assist in specifying which variables should be included in the final model. Following individual Cox Proportional Hazard analysis for each personality predictor, significant personality predictors were included in one final Cox Proportional Hazards Model to assess for personality effects of return to play controlling for other significant personality predictors. Cox Proportional Hazards analysis results in parameter estimates that are in the metric of log. To interpret these parameter estimates, they were exponentiated to find a hazard ratio (HR), or the risk of outcome occurrence given a certain interval of time (Singer & Willett, 2003). HRs, or the relative risk of return to play in this study, will be referred to as relative risk (RR) estimates. These estimates were interpreted as the percent change in risk of return to play for every one unit increase in each personality construct. These estimates are presented with relevant confidence intervals (CIs).

Prior to running the hypothesized logistic regression models, logistic regression analyses were conducted to assess the general relation between the personality factors of interest and binary sports-related concussion (no/yes) and undiagnosed sports-related concussion (no/yes) variables holding constant injury severity. The first set of models included the sports-related concussion variable regressed on each personality factor of interest in separate models. The second set of models included the undiagnosed sports-related concussion variable regressed on each personality factor of interest in separate models. Parameter estimates in logistic regression are in the metric of log of the odds of the outcome given the predictors. For this reason, parameter estimates are generally exponentiated to find the odds ratios (ORs; Wright, 1995). The odds ratios in the current study were transformed into percent change in likelihood of the outcome such that for every one unit increase in a personality construct, the percent change in the outcome was reported.

Logistic regression was used to assess whether subsequent concussions occurred following an initial sports-related concussion (Hypothesis 2). Several models were created with predictors that included the 3 first order factors of impulsivity derived from both the BIS-11 as well as the mean time estimation score and percent inhibited in the GoStop task from the Laboratory Measures of Behavioral Impulsivity, experience seeking and risk seeking as measured by the Sensation Seeking Personality Type Scale, and the Big Five factors of personality, to assess the predictive power of these personality traits in determining the likelihood of subsequent concussion. ORs were interpreted as percent change in likelihood of subsequent concussion.

Exploratory Factor Analysis (EFA) was used to investigate the factor structure of the 22 protective behavioral strategies. Factor loadings, communalities, uniquenesses, conceptual interpretability, and results of a parallel analysis were considered in interpreting the results of the EFA. Fit indices are not presented here as a result of evidence that examining fit for unrestricted exploratory models can often lead to erroneous conclusions (Garrido et al., 2016). It has been found that fit indices used for unrestricted models are especially sensitive to sample size, categorical variables, and skewness of variables. For this reason, it is recommended to rely on Horn's parallel analysis, factor loadings, and conceptual interpretability for determination of a factor solution in EFA. The percent variance in the 22 items that the factor solution explained was also considered in determining the proper factor solution for these data. This analysis also allowed for the proper interpretation and use of these protective behavioral strategies in subsequent analysis. Both Cronbach's alpha (α) and McDonald's omega (Ω) reliability coefficients were used to evaluate reliability. Cronbach's alpha, a measure of internal consistency, does not provide sufficient information to establish that items are homogeneous (McDonald, 1999). Cronbach's alpha can underestimate true reliability, while McDonald's omega is increasingly viewed as a more direct measure of reliability due the use of factor loadings to estimate true score variance. Cronbach's alpha was used here to examine item interrelatedness, while McDonald's omega was used to examine homogeneity among items.

Logistic regression and multiple linear regression were both used to assess the use of protective behavioral strategies (Hypothesis 3). The first set of analyses were logistic regressions that used a protective behavioral strategy binary variable that was created by including the 75th percentile and above of strategy use coded as a “1”, while the 50th percentile and below of strategy use was coded as a “0”. Impulsivity, sensation seeking, and Big Five personality predictors were investigated for their relation to the likelihood of protective behavioral strategy use. ORs from the logistic regression analysis were interpreted as percent change in likelihood of using protective behavioral strategies at the 75th percentile or above when compared to protective behavioral strategy use at the 50th percentile or below. Additionally, multiple linear regression was utilized to assess the association between personality predictors on the number of protective behavioral strategies used when protective behavioral strategies were included as one continuous variable. This multiple linear regression analysis was conducted in addition to the logistic regression analysis to assess for the effects of personality at all levels of protective behavioral strategy use. Parameter estimates for these linear regressions were interpreted as the unit change in protective behavioral strategy use for every one unit increase in a personality construct.

For all regression analyses parameter estimates, standard errors, p-values, and confidence intervals were examined for significance and interpretation of results. Due to the largely exploratory nature of these analyses, alpha was set at .05 for all hypotheses. Thus, all analyses resulting in a p-value less than .05 were considered significant findings. Analysis for all hypotheses controlled for the effects of injury severity on the relevant outcomes. Injury severity was assessed with a question asking, “Did you lose consciousness as a result of this injury?”. This was a binary variable with 90 (24.1%) participants reporting that they did lose consciousness as a result of their first sports-related concussion.

CHAPTER 3: RESULTS

Hypothesis 1: Survival Analysis of Time to Return to Play

337 participants had complete data for return to play following an initial concussion. 23 of these participants (6.8%) were censored and had not returned to play the time they completed this study. The majority of participants (93.2%) returned to play at some point following an initial concussion. 1 outlier was excluded from analysis that reported return to play after 624 weeks, or 12 years. Subsequent analyses were conducted on the 313 participants who returned to play before data collection for this study. Time to return to play was measured in weeks, with participants returning to play at 19.4 weeks after the injury on average. The median number of weeks for return to play in this sample was 2 weeks, with a range of return to play responses between 0 weeks (immediately) and 260 weeks, or 5 years.

The survival data are included in Table 6 and the corresponding plot is shown in Figure 1. These data show the probability of not experiencing the event, or the probability of not returning to play. Each time a time interval is presented in the table, at least 1 person in the sample returned to play at that time.

The cumulative hazard function is depicted in Figure 2. The cumulative hazard function represents the total amount of accumulated risk at a given point in time (weeks). These plots are to be interpreted generally, without focusing on the absolute value of the curve. This cumulative hazard plot shows that risk of return to play is highest and rapidly increases between 0 and approximately 20 weeks. Accumulated risk gradually increases through 260 weeks.

Table 6: Survival Data

time	n.risk	n.event	survival	SE	95% CI
0.0	313	43	0.8626	0.0195	0.8193 - 0.8962
0.5	270	19	0.8019	0.0225	0.7533 - 0.8420
1.0	251	44	0.6613	0.0268	0.6060 - 0.7108
1.5	207	10	0.6294	0.0273	0.57332 - 0.6802
2.0	197	49	0.4728	0.0282	0.4166 - 0.5259
2.5	148	6	0.4537	0.0281	0.3978 - 0.5078
3.0	142	26	0.3706	0.0273	0.3173 - 0.4239
3.5	116	1	0.3674	0.0273	0.3142 - 0.4206
4.0	115	37	0.2492	0.0245	0.2028 - 0.2982
5.0	77	2	0.2427	0.0242	0.1968 - 0.2914
6.0	75	7	0.2201	0.0234	0.1759 - 0.2675
8.0	68	16	0.1683	0.0212	0.1291 - 0.2119
12.0	52	6	0.1489	0.0202	0.1119 - 0.1908
14.0	46	1	0.1456	0.0200	0.1091 - 0.1872
16.0	45	1	0.1424	0.0198	0.1063 - 0.1837
24.0	44	3	0.1327	0.0192	0.0978 - 0.1730
36.0	41	2	0.1252	0.0188	0.0922 - 0.1658
52.0	39	10	0.0939	0.0166	0.0647 - 0.1295
56.0	29	1	0.0906	0.0163	0.0620 - 0.1258
78.0	28	1	0.0874	0.0160	0.0593 - 0.1221
104.0	27	9	0.0583	0.0133	0.0359 - 0.0882
156.0	18	8	0.0324	0.0101	0.0166 - 0.0566
208.0	10	5	0.0162	0.00728	0.0062 - 0.0354
260.0	5	5	0.000	-	-

Note: 1 Observation deleted due to missingness

Figure 1. Survival curve plot.

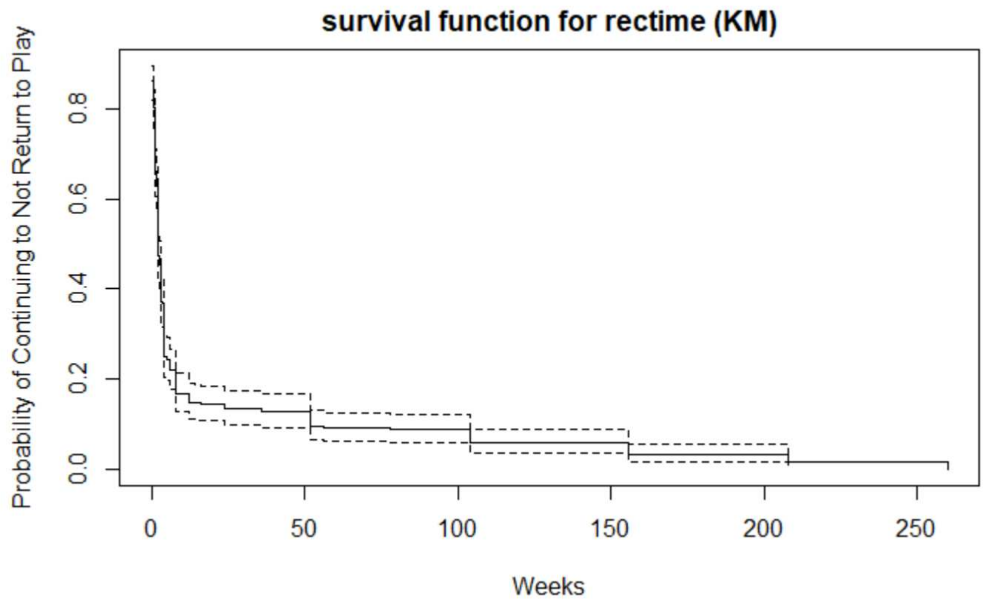
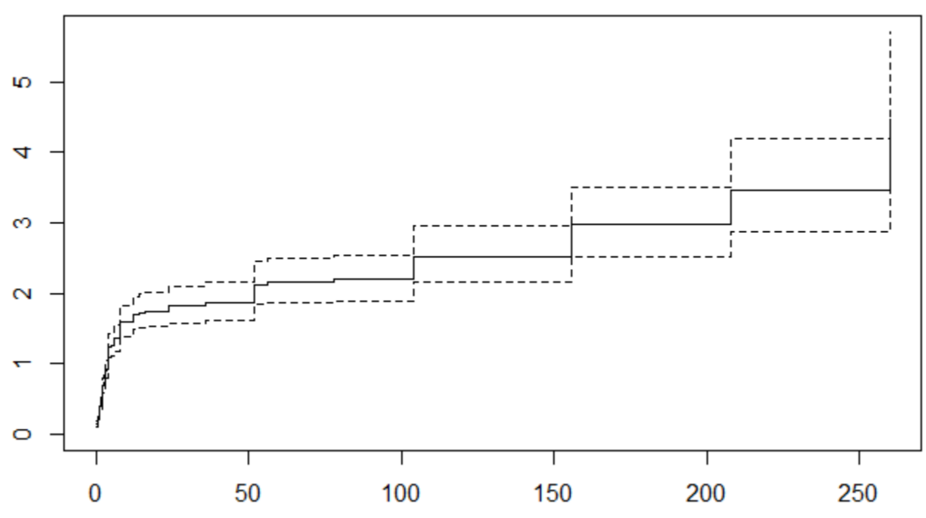


Figure 2. Cumulative hazard curve plot. Total amount of accumulated risk at a given point in time.



Kaplan Meier and logrank results indicated that those low in experience seeking had a higher probability of not returning to play than those in the high experience seeking group, $\chi2 = 5.9$, df

= 1, p = .02. Those low in risk seeking had a higher probability of not returning to play than those high in risk seeking $\chi2$ = 5.8, df = 1, p = .02, those low in mean time estimation had a higher probability of not returning to play than those who estimated a minute to be longer, $\chi2$ = 5.6, df = 1, p = .02, and those with lower percent inhibited had a higher probability of not returning to play than those who had a higher percent inhibited following an initiated response (p = .03). These relations are depicted in Figures 3-6.

Figure 3. Survival probability curve for participants with higher levels of experience seeking (ESgroup=2) and lower levels of experience seeking (ESgroup=1).

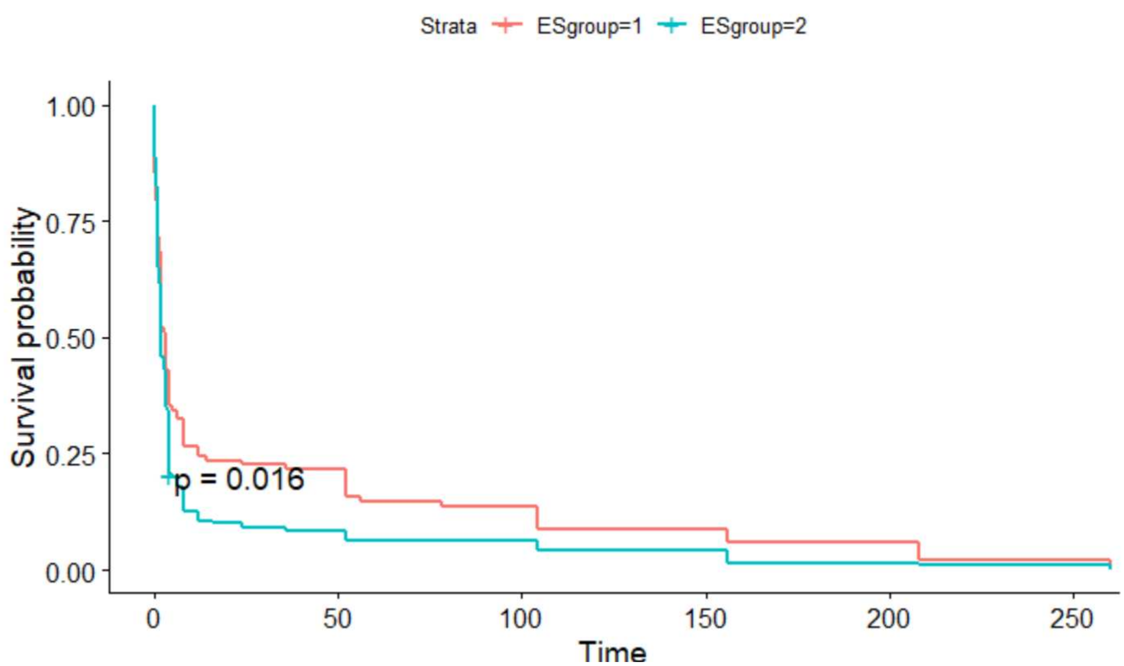


Figure 4. Survival probability curve for participants with higher levels of risk seeking (RSgroup=2) and lower levels of risk seeking (RSgroup=1).

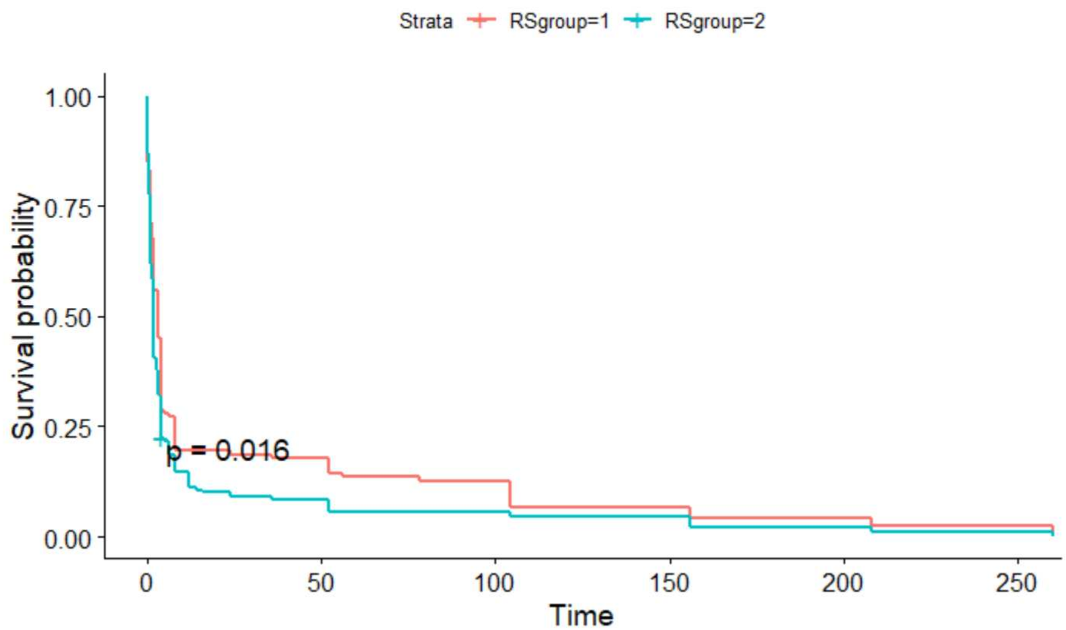


Figure 5. Survival probability curve for participants with higher levels of mean time estimation (mean_timegroup=2) and lower levels of mean time estimation (mean_timegroup=1).

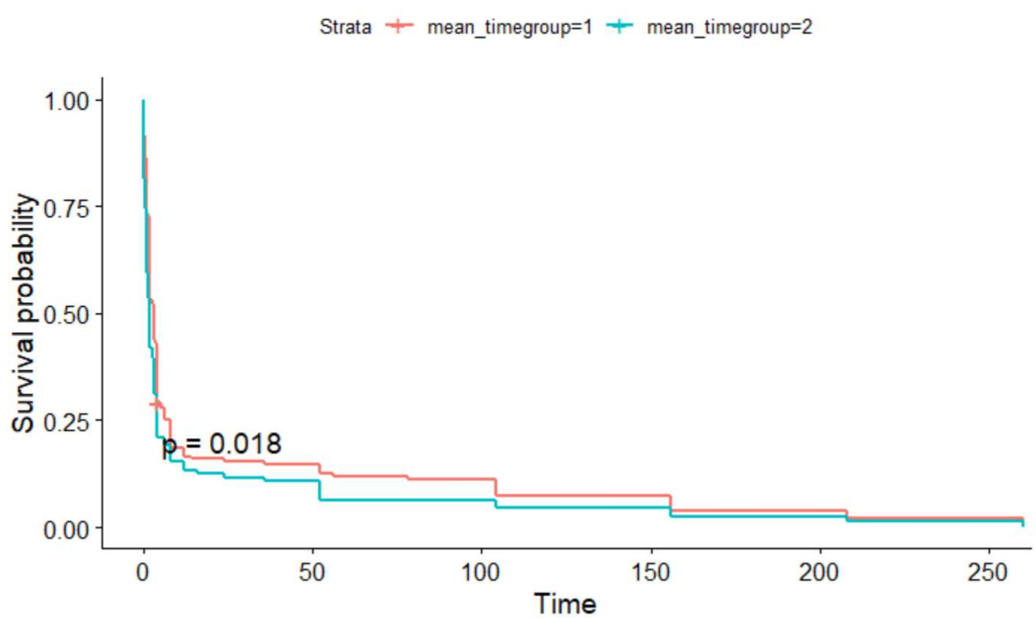
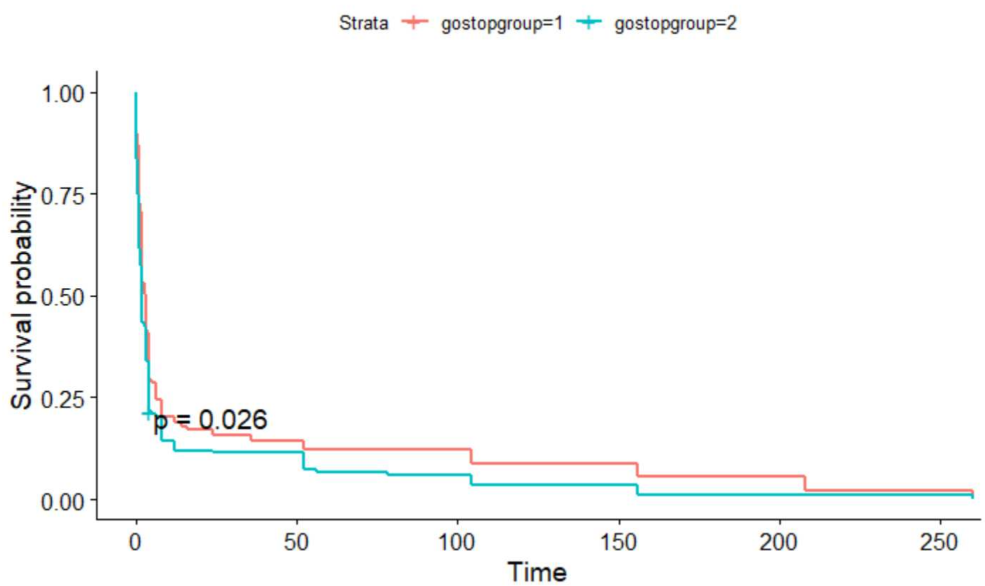


Figure 6. Survival probability curve for participants with higher levels of percent trials inhibited after an initiated response (gostopgroup=2) and lower levels of percent trials inhibited after an initiated response (gostopgroup=1).



Following descriptive Kaplan Meier analysis, Cox Proportional Hazards models were run, regressing hazard of return to play on each continuous personality variable in a separate model holding constant injury severity. Parameter estimates, relative risk estimates (RR), standard errors (se), and 95% CIs for all results, both significant and non-significant, are included in Table A2 in the Appendix. Experience seeking, risk seeking, conscientiousness, and percent inhibited emerged as significant predictors of hazard of return to play.

Positive Associations with Time to Return to Play

- Hazard of returning to play is 6.5% higher for every one unit increase in experience seeking (b = 0.063, SE = 0.023, p = .007, RR = 1.065, CI [1.018 - 1.114]).
- Hazard of returning to play is 3.7% higher for every one unit increase in risk seeking (b = 0.036, SE = 0.016, p = 0.02, RR = 1.037, CI [1.005 - 1.070]).

- Hazard of returning to play is 0.4% higher for every one unit increase in percent inhibited (b = 0.004, SE = 0.002, p = .04, RR = 1.004, CI [1.000 - 1.008]).

Negative Associations with Time to Return to Play

- Hazard of returning to play is 5.1% lower for every one unit increase in conscientiousness (b = -0.052, SE = 0.025, p = .03, RR = 0.949, CI [0.904 - 0.997]).

When these significant predictors were all included in the final Cox Proportional Hazard model, none of these predictors emerged as significant when controlling for other significant predictors of hazard.

Hypothesis 2: Logistic Regression Analysis of Likelihood of Subsequent Concussion

Regarding sports-related concussion in general, experience seeking, risk seeking, non-planning impulsivity, motor impulsivity, openness to experience, conscientiousness, extraversion, neuroticism, and percent inhibited were found to be significantly associated with a greater chance of reporting a history of at least 1 sports-related concussion when compared to no reported history of sports-related concussion, holding constant injury severity. Agreeableness and mean time estimation were found to be significantly associated with a lower chance of reporting a history of at least 1 sports-related concussion when compared to no reported history of sports-related concussion, holding constant injury severity. Table A3 in the Appendix includes all significant and non-significant results.

Positive Associations with History of Sports-Related Concussion

- For every one unit increase in experience seeking, there are 8.9% greater odds of reporting a history of at least 1 sports-related concussion than reporting no history of sports-related concussion holding constant injury severity ($b = 0.085$, $SE = 0.005$, $p < .001$, $OR = 1.089$, CI [1.078 - 1.101]).
- For every one unit increase in risk seeking, there are 6.6% greater odds of reporting a history of at least 1 sports-related concussion than reporting no history of sports-related concussion holding constant injury severity ($b = 0.064$, $SE = 0.004$, $p < .001$, $OR = 1.066$, CI [1.059 - 1.074]).
- For every one unit increase in conscientiousness, there are 2.3% greater odds of reporting a history of at least 1 sports-related concussion than reporting no history of sports-related concussion holding constant injury severity ($b = 0.023$, $SE = 0.006$, $p < .001$, $OR = 1.023$, CI [1.012 - 1.035]).
- For every one unit increase in openness to experience, there are 3.6% greater odds of reporting a history of at least 1 sports-related concussion than reporting no history of sports-related concussion holding constant injury severity ($b = 0.035$, $SE = 0.007$, $p < .001$, $OR = 1.036$, CI [1.022 - 1.050]).
- For every one unit increase in extraversion, there are 9.9% greater odds of reporting a history of at least 1 sports-related concussion than reporting no history of sports-related concussion holding constant injury severity ($b = 0.095$, $SE = 0.004$, $p < .001$, $OR = 1.099$, CI [1.089 - 1.110]).
- For every one unit increase in neuroticism, there are 7% greater odds of reporting a history of at least 1 sports-related concussion than reporting no history of sports-related

concussion holding constant injury severity ($b = 0.068$, $SE = 0.005$, $p < .001$, $OR = 1.070$, CI [1.060 - 1.081]).

- For every one unit increase in non-planning impulsivity, there are 2.3% greater odds of reporting a history of at least 1 sports-related concussion than reporting no history of sports-related concussion holding constant injury severity ($b = 0.023$, $SE = 0.003$, $p < .001$, $OR = 1.023$, CI [1.017 - 1.029]).
- For every one unit increase in motor impulsivity, there are 4.7% greater odds of reporting a history of at least 1 sports-related concussion than reporting no history of sports-related concussion holding constant injury severity ($b = 0.046$, $SE = 0.003$, $p < .001$, $OR = 1.047$, CI [1.040 - 1.054]).
- For every one unit increase in percent inhibited, there are 0.1% greater odds of reporting a history of at least 1 sports-related concussion than reporting no history of sports-related concussion holding constant injury severity ($b = 0.001$, $SE = 0.0005$, $p = .04$, $OR = 1.001$, CI [1.000 - 1.002]).

Negative Associations with History of Sports-Related Concussion

- For every one unit increase in agreeableness, there are 5.7% lower odds of reporting a history of at least 1 sports-related concussion than reporting no history of sports-related concussion holding constant injury severity ($b = -0.058$, $SE = 0.007$, $p < .001$, $OR = 0.943$, CI [0.931 - 0.956]).
- For every one unit increase in mean time estimation, there are 0.9% lower odds of reporting a history of at least 1 sports-related concussion than reporting no history of sports-related concussion holding constant injury severity ($b = -0.009$, $SE = 0.002$, $p < .001$, $OR = 0.991$, CI [0.988 - 0.994]).

Regarding undiagnosed sports-related concussion, risk seeking, extraversion, attentional impulsivity, motor impulsivity, mean time estimation, percent inhibited were found to be significantly associated with a greater chance of reporting a history of at least 1 undiagnosed concussion in comparison with reporting no history of an undiagnosed concussion holding constant injury severity. Neuroticism, agreeableness, conscientiousness, and experience seeking were found to be significantly associated with a lower chance of reporting a history of at least 1 undiagnosed concussion in comparison with reporting no history of undiagnosed concussion holding constant injury severity. Table A4 in the Appendix includes all significant and non-significant results.

Positive Associations with History of Undiagnosed Sports-Related Concussion

- For every one unit increase in risk seeking, there are 6.9% greater odds of reporting an undiagnosed sports-related concussion than not reporting an undiagnosed concussion holding constant injury severity ($b = 0.067$, $SE = 0.006$, $p < .001$, $OR = 1.069$, CI [1.056 - 1.083]).
- For every one unit increase in extraversion, there are 1.9% greater odds of reporting an undiagnosed sports-related concussion than not reporting an undiagnosed concussion holding constant injury severity ($b = 0.019$, $SE = 0.008$, $p = .02$, $OR = 1.019$, CI [1.003 - 1.035]).
- For every one unit increase in attentional impulsivity, there are 4.6% greater odds of reporting an undiagnosed sports-related concussion than not reporting an undiagnosed concussion holding constant injury severity ($b = 0.045$, $SE = 0.006$, $p < .001$, $OR = 1.046$, CI [1.034 - 1.058]).

- For every one unit increase in motor impulsivity, there are 2.9% greater odds of reporting an undiagnosed sports-related concussion than not reporting an undiagnosed concussion holding constant injury severity ($b = 0.029$, $SE = 0.006$, $p < .001$, $OR = 1.029$, CI [1.018 - 1.041]).
- For every one unit increase in percent inhibited following an initiated response, there are 0.3% greater odds of reporting an undiagnosed sports-related concussion than not reporting an undiagnosed concussion holding constant injury severity ($b = 0.003$; $SE = 0.001$, $p < .001$, $OR = 1.003$, CI [1.002 - 1.005]).
- For every one unit increase in mean time estimation, there are 1.7% greater odds of reporting an undiagnosed sports-related concussion than not reporting an undiagnosed concussion holding constant injury severity ($b = 0.017$; $p < .001$, $SE = 0.003$, $OR = 1.017$, CI [1.012 - 1.022]).

Negative Associations with History of Undiagnosed Sports-Related Concussion

- For every one unit increase in experience seeking, there are 3% lower odds of reporting an undiagnosed sports-related concussion than not reporting an undiagnosed concussion holding constant injury severity ($b = -0.030$, $SE = 0.009$, $p < .001$, $OR = 0.970$, CI [0.954 - 0.987]).
- For every one unit increase in conscientiousness, there are 3.8% lower odds of reporting an undiagnosed sports-related concussion than not reporting an undiagnosed concussion holding constant injury severity ($b = -0.039$, $SE = 0.010$, $p < .001$, $OR = 0.962$, CI [0.944 - 0.980]).
- For every one unit increase in agreeableness, there are 10% lower odds of reporting an undiagnosed sports-related concussion than not reporting an undiagnosed concussion

holding constant injury severity (b = -0.105, SE = 0.011, p <.001, OR = 0.90, CI [0.880 - 0.920]).

- For every one unit increase in neuroticism, there are 6.3% lower odds of reporting an undiagnosed sports-related concussion than not reporting an undiagnosed concussion holding constant injury severity (b = 0.064, SE = 0.008, p <.001, OR = 0.933, CI [0.923 - 0.953]).

Hypothesis 2A/2B

171 participants who reported at least 1 sports-related concussion reported that they have experienced 2 or more sports-related concussions, and 178 participants reported sustaining 1 sports-related concussion. This binary concussion outcome variable (1 concussion/2+ concussions) was regressed on each personality factor in separate logistic regression models. Risk seeking, attentional impulsivity, motor impulsivity, non-planning impulsivity, extraversion, neuroticism, and mean time estimation were found to be significantly associated with a greater likelihood of reporting a history of 2 or more sports related concussions compared to reporting a history of 1 sports-related concussion holding constant injury severity. Openness to experience, agreeableness, and percent inhibited were found to be significantly associated with a lower likelihood of reporting a history of 2 or more sports-related concussions compared to reporting a history of 1 sports-related concussion holding constant injury severity. Table A5 in the Appendix includes all significant and non-significant results.

Positive Associations with History of 2 or More Sports-Related Concussions

- For every one unit increase in risk seeking, there are 7.5% greater odds of reporting a history of 2 or more sports-related concussions than reporting a history of 1 sports related concussion holding constant injury severity (b = 0.072, SE= 0.006, p = < .001, OR = 1.075, CI [1.063 - 1.087]).

- For every one unit increase in neuroticism, there are 2.5% greater odds of reporting a history of 2 or more sports-related concussions than reporting a history of 1 sports related concussion holding constant injury severity (b = 0.024, SE = 0.007, p <.001, OR = 1.025, CI [1.010 - 1.039]).
- For every one unit increase in extraversion, there are 3.4% greater odds of reporting a history of 2 or more sports-related concussions than reporting a history of 1 sports related concussion holding constant injury severity (b = 0.033, SE = 0.007, p <.001, OR = 1.034, CI [1.020 - 1.048]).
- For every one unit increase in attentional impulsivity, there are 5.5% greater odds of reporting a history of 2 or more sports-related concussions than reporting a history of 1 sports related concussion holding constant injury severity (b = 0.053, SE = 0.005, p = < .001, OR = 1.055, CI [1.044 - 1.065]).
- For every one unit increase in motor impulsivity, there are 2.9% greater odds of reporting a history of 2 or more sports-related concussions than reporting a history of 1 sports related concussion holding constant injury severity (b = 0.029, SE = 0.005, p < .001, OR = 1.029, CI [1.019 - 1.039]).
- For every one unit increase in non-planning impulsivity, there are 0.9% greater odds of reporting a history of 2 or more sports-related concussions than reporting a history of 1 sports related concussion holding constant injury severity (b = 0.009, SE = 0.004, p = .03, OR = 1.009, CI [1.001 - 1.018]).

- For every one unit increase in mean time estimation, there are 0.9% greater odds of reporting a history of 2 or more sports-related concussions than reporting a history of 1 sports related concussion holding constant injury severity ($b = 0.009$, $SE = 0.002$, $p < .001$, $OR = 1.009$, CI [1.005 - 1.014]).

Negative Associations with History of 2 or More Sports-Related Concussions

- For every one unit increase in openness to experience, there are 4.1% lower odds of reporting a history of 2 or more sports-related concussions than reporting a history of 1 sports related concussion holding constant injury severity ($b = -0.041$, $SE = 0.010$, $p < .001$, $OR = 0.959$, CI [0.941 - 0.979]).
- For every one unit increase in agreeableness, there are 3% lower odds of reporting a history of 2 or more sports-related concussions than reporting a history of 1 sports related concussion holding constant injury severity ($b = -0.030$, $SE = 0.010$, $p = .002$, $OR = 0.970$, CI [0.952 - 0.989]).
- For every one unit increase in percent inhibited following an initiated response, there are 0.9% lower odds of reporting a history of 2 or more sports-related concussions than reporting a history of 1 sports related concussion holding constant injury severity ($b = -0.009$, $SE =0 .001$, $p < .001$, $OR = 0.990$, CI [0.989 - 0.992]).

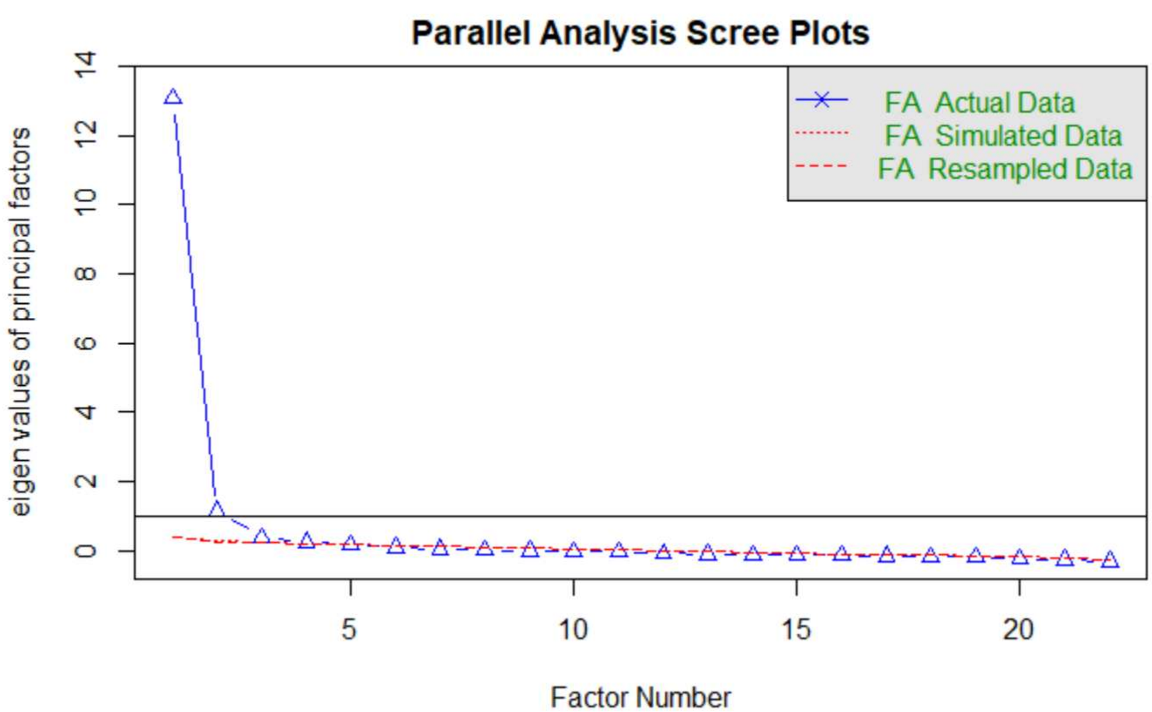
Hypothesis 3: Logistic Regression and Multiple Linear Regression Analyses of the Likelihood and Frequency of Protective Behavioral Strategy Use

Exploratory Factor Analysis (EFA) Results

An exploratory factor analysis was conducted for the 22 protective behavioral strategies created to represent strategies that can be done before, during, and after a concussion to reduce harm that may result from concussion. The purpose of this analysis was to discover the number of factors in these items.

The scree plot shows that eigenvalues "level off" after the first factor. A subsequent parallel analysis showed that the eigenvalues of the randomly generated data exceeded the eigenvalues of the sample data starting with the fifth factor (Figure 7). As a result, a 4 factor solution was suggested. However, examination of the eigenvalues shows that that the first eigenvalue is 13.06, significantly larger than 1. The second eigenvalue is 1.1, just slightly larger than 1. Further, interpretability of a 1 factor solution for these data is strong. As a result of 1 eigenvalue being significantly larger than 1 as well as a leveling off of the scree plot after 1 factor, these data and items warrant a 1 factor solution based on these criteria.

Figure 7. Parallel analysis scree plot. As described in text, there is a leveling off after 1 factor, hence the 1 factor solution was decided to be the most representative of these items.



This factor explains 59.3% of the variance in these items. Strong factor loadings and conceptual meaning of the factor solution carry more weight than fit at the exploratory stage. Additionally, after examination of 2, 3, and 4 factor solutions, most items had cross loadings on multiple factors. For these reasons, a 1 factor solution was used for subsequent analysis such that a total score for protective behavioral strategy use was utilized in hypothesis 3 analyses.

Table 7: Exploratory Factor Analysis Factor Loadings, Communalities, and Uniquenesses

	Factor Loadings	h^2	u^2
Item 1	.61	.37	.63
Item 2	.67	.45	.55
Item 3	.38	.15	.85
Item 4	.68	.46	.54
Item 5	.68	.46	.54
Item 6	.72	.52	.48
Item 7	.73	.53	.47
Item 8	.68	.46	.54
Item 9	.70	.49	.51
Item 10	.77	.60	.40
Item 11	.71	.51	.49
Item 12	.72	.52	.48
Item 13	.63	.40	.60
Item 14	.71	.51	.49
Item 15	.62	.39	.61
Item 16	.65	.43	.57
Item 17	.62	.38	.62
Item 18	.68	.46	.54
Item 19	.49	.24	.76
Item 20	.60	.35	.65
Item 21	.56	.31	.69
Item 22	.71	.51	.49

Since a 1 factor solution was supported for these data, factor rotation is not necessary. A 1 factor solution for these items shows good internal consistency ($\alpha = .94$), as well as strong evidence for homogeneity ($\Omega = .94$). Factor loadings ranged from .38 to .77. All factor loadings, communalities, and uniquenesses are included in Table 7. Additional information including mean, skewness, kurtosis, and Cronbach's alpha for each item are included in Table 8.

Table 8: Mean, Skewness, Kurtosis, and Cronbach's Alpha for Each Item

	Mean	Skewness	Kurtosis	Cronbach's α
Item 1	3.64	.407	-1.218	.940
Item 2	4.07	.113	-1.414	.940
Item 3	5.10	-.351	-1.40	.943
Item 4	3.55	.423	-1.165	.939
Item 5	3.80	.305	-1.342	.939
Item 6	3.51	.438	-1.220	.938
Item 7	3.53	.422	-1.234	.938
Item 8	4.46	-.106	-1.460	.939
Item 9	3.57	.453	-1.107	.938
Item 10	3.91	.150	-1.439	.937
Item 11	4.71	-.231	-1.519	.938
Item 12	3.99	.212	-1.486	.938
Item 13	3.02	.760	-.644	.939
Item 14	4.75	-.259	-1.466	.938
Item 15	3.65	.336	-1.348	.939
Item 16	3.87	.249	-1.488	.939
Item 17	4.75	-.217	-1.528	.939
Item 18	4.57	-.125	-1.60	.938
Item 19	5.24	-.499	-1.29	.941
Item 20	4.87	-.301	-1.446	.940
Item 21	5.81	-.799	-.943	.940
Item 22	4.40	.016	-1.503	.938

Future Confirmatory Factor Analysis will investigate the extent to which this factor structure is hierarchical with one overarching protective behavioral strategy factor, made up of 3 or 4 sub-factors. Future analysis will also investigate the necessity of item 3 in the scale as a result of a fairly low factor loading (.38).

Hypothesis 3A

The binary protective behavioral strategy outcome variable (50th percentile and below for protective behavioral strategy use/75th percentile and above for protective behavioral strategy use) was regressed on each personality factor in separate logistic regression models, holding constant injury severity. Further, each model was run on the sample that was filtered to only include those who reported experiencing at least 1 sports related-concussion. Conscientiousness, neuroticism, and agreeableness were found to be significantly associated with a greater chance of using protective behavioral strategies in the 75th percentile or above as compared to the 50th percentile or below holding constant injury severity. Experience seeking, risk seeking, non-planning impulsivity, attentional impulsivity, motor impulsivity, extraversion, mean time estimation, and percent inhibited were found to be significantly associated with a lower chance of using protective behavioral strategies in the 75th percentile or above as compared to the 50th percentile or below, holding constant injury severity. Table A6 in the Appendix includes all significant and non-significant results.

Positive Associations with Protective Behavioral Strategy Use

- For every one unit increase in conscientiousness, there are 14.1% greater odds of using protective behavioral strategies in the 75th percentile or above than using these strategies at the 50^{th} percentile or below holding constant injury severity ($b = 0.132$, $SE = 0.007$, $p < .001$, $OR = 1.141$, CI [1.126 - 1.157]).

- For every one unit increase in neuroticism, there are 2.3% greater odds of using protective behavioral strategies in the 75^{th} percentile or above than using these strategies at the 50^{th} percentile or below holding constant injury severity ($b = 0.023$, $SE = 0.005$, $p < .001$, $OR = 1.023$, CI [1.012 - 1.033]).
- For every one unit increase in agreeableness, there are 4.2% greater odds of using protective behavioral strategies in the 75^{th} percentile or above than using these strategies at the 50^{th} percentile or below holding constant injury severity ($b = 0.041$, $SE = 0.007$, $p < .001$, $OR = 1.042$, CI [1.027 - 1.057]).

Negative Associations with Protective Behavioral Strategy Use

- For every one unit increase in experience seeking, there are 6.1% lower odds of using protective behavioral strategies in the 75^{th} percentile or above than using these strategies at the 50^{th} percentile or below holding constant injury severity ($b = -0.063$, $SE = 0.006$, $p < .001$, $OR = 0.939$, CI [0.929 - 0.950]).
- For every one unit increase in risk seeking, there are 11.2% lower odds of using protective behavioral strategies in the 75^{th} percentile or above than using these strategies at the 50^{th} percentile or below holding constant injury severity ($b = -0.120$, $SE = 0.004$, $p < .001$, $OR = 0.888$, CI [0.881 - 0.896]).
- For every one unit increase in extraversion, there are 2.8% lower odds of using protective behavioral strategies in the 75^{th} percentile or above than using these strategies at the 50^{th} percentile or below holding constant injury severity ($b = -0.027$, $SE = 0.005$, $p < .001$, $OR = 0.972$, CI [0.963 - 0.982]).

- For every one unit increase in non-planning impulsivity, there are 9.1% lower odds of using protective behavioral strategies in the 75th percentile or above than using these strategies at the 50th percentile or below holding constant injury severity ($b = -0.095$, $SE = 0.004$, $p < .001$, $OR = 0.909$, CI [0.903 - 0.916]).
- For every one unit increase in attentional impulsivity, there are 7.5% lower odds of using protective behavioral strategies in the 75th percentile or above than using these strategies at the 50th percentile or below holding constant injury severity ($b = -0.077$, $SE = 0.004$, $p < .001$, $OR = 0.925$, CI [0.918 - 0.933]).
- For every one unit increase in motor impulsivity, there are 8.2% lower odds of using protective behavioral strategies in the 75th percentile or above than using these strategies at the 50th percentile or below holding constant injury severity ($b = -0.084$, $SE = 0.004$, $p < .001$, $OR = 0.918$, CI [0.912 - 0.926]).
- For every one unit increase in mean time estimation, there are 1.3% lower odds of using protective behavioral strategies in the 75th percentile or above than using these strategies at the 50th percentile or below holding constant injury severity ($b = -0.012$, $SE = 0.002$, $p < .001$, $OR = 0.987$, CI [0.984 - 0.991]).
- For every one unit increase in percent inhibited, there are 0.7% lower odds of using protective behavioral strategies in the 75th percentile or above than using these strategies at the 50th percentile or below holding constant injury severity ($b = -0.006$, $SE = 0.001$, $p < .001$, $OR = 0.993$, CI [0.099 - 0.993]).

Hypothesis 3B/3C

Protective behavioral strategy use was transformed into a total score variable with each individual receiving a score for their overall protective behavioral strategy use across all 22 strategies. This variable was continuous and normally distributed in a sample filtered to only include those that reported experiencing at least 1 sports-related concussion. This protective behavioral strategy use variable was regressed on each personality factor in separate linear regression models holding constant injury severity. Each model was run on the sample of individuals who reported experiencing at least 1 sports-related concussion. Neuroticism, conscientiousness, and agreeableness were found to be positively and significantly associated with protective behavioral strategy use holding constant injury severity. Experience seeking, risk seeking, non-planning impulsivity, attentional impulsivity, motor impulsivity, mean time estimation, and percent inhibited following an initiated response were found to be significantly and negatively associated with protective behavioral strategy use holding constant injury severity. Table A7 in the Appendix includes all significant and non-significant results.

Positive Associations with Protective Behavioral Strategy Use

- For every one unit increase in neuroticism, protective behavioral strategy use increases by 2.034 units holding constant injury severity ($b = 2.034$, $SE = 0.137$, $p < .001$, CI [1.765 - 2.302]).
- For every one unit increase in conscientiousness, protective behavioral strategy use increases by 2.202 units holding constant injury severity ($b = 2.202$, $SE = 0.171$, $p < .001$, CI [1.533 - 2.067]).

Negative Associations with Protective Behavioral Strategy Use

- For every one unit increase in experience seeking, protective behavioral strategy use decreases by 1.062 units holding constant injury severity ($b = -1.062$, $SE = 0.154$, $p < .001$, CI [-1.364 - -0.760]).
- For every one unit increase in risk seeking, protective behavioral strategy use decreases by 2.111 units holding constant injury severity ($b = -2.111$, $SE = 0.103$, $p < .001$, CI [-2.313 - -1.909]).
- For every one unit increase in openness to experience, protective behavioral strategy use decreases by 0.824 units holding constant injury severity ($b = -0.824$, $SE = 0.209$, $p < .001$, CI [-1.203 - -0.564]).
- For every one unit increase in extraversion, protective behavioral strategy use decreases by 0.493 units holding constant injury severity ($b = -0.493$, $SE = 0.133$, $p < .001$, CI [-0.732 - -0.314]).
- For every one unit increase in non-planning impulsivity, protective behavioral strategy use decreases by 1.666 units holding constant injury severity ($b = -1.666$, $SE = 0.089$, $p < .001$, CI [-1.484 - -1.205]).
- For every one unit increase in attentional impulsivity, protective behavioral strategy use decreases by 1.519 units holding constant injury severity ($b = -1.519$, $SE = 0.103$, $p < .001$, CI [-1.423 - -1.104]).
- For every one unit increase in motor impulsivity, protective behavioral strategy use decreases by 1.418 units holding constant injury severity ($b = -1.418$, $SE = 0.099$, $p < .001$, CI [-1.346 - -1.036]).

- For every one unit increase in mean time estimation, protective behavioral strategy use decreases by 0.186 units holding constant injury severity (b = -0.186, SE = 0.051, p = .001, CI [-0.216 - -0.056]).
- For every one unit increase in percent inhibited, protective behavioral strategy use decreases by 0.198 units holding constant injury severity (b = -0.198, SE = 0.015, p < .001, CI [-0.174 - -0.127]).

Subsequent t-tests showed that there was not a significant difference in the total protective behavioral strategy use between those who experienced a sports-related concussion and those who did not. Those who did not report a sports-related concussion reported higher total prevention strategy use (M = 91.50, SD = 58.10) than those who did report a concussion (M = 88.63, SD = 42.56; t(695) = 0.72, p = .47, CI [-10.70 - 4.96]). However, those who did not experience a sports-related concussion were not incorporated into regression analysis for protective behavioral strategy use in this study.

CHAPTER 4: DISCUSSION

The current study found significant differences in time to return to play depending upon personality traits. With typical return to play protocol for sports-related concussion taking place within 7-10 days, the median reported return to play in this sample of 2 weeks demonstrates that most people in this sample followed a fairly average trajectory of return to play. However, the range of return to play in this sample spanned from 1 day to 260 weeks, or 5 years. These data support the idea that return to play is a wide-ranging and highly individualized process. Findings show that experience seeking and risk seeking are the strongest predictors of returning to play more quickly, while conscientiousness is the strongest predictor of returning to play more slowly. Following a sports-related concussion, those high in experience seeking likely find the recovery process less stimulating and less novel, and as a result return to play more rapidly to maintain their optimal level of stimulation. For those high in risk seeking, returning to play more quickly and perhaps prematurely may be a result of lower risk appraisal. Those who are higher in risk seeking may not be as concerned with or worried about subsequent injury because of a willingness to experience risk for the sake of the experience. A core aspect of high levels of conscientiousness is a drive to be diligent, follow rules, and to take obligations seriously (Poropat, 2009). As a result, those high in conscientiousness most likely have the highest chance of being mindful about the recommendations of doctors, trainers, and education about concussion in general when going through the recovery process. These analyses controlled for injury severity, meaning that these results for experience seeking, risk seeking, and conscientiousness are significant across a range of injury severity within the sample. This is important to note because injury severity is a primary variable that could be expected to impact return to play behaviors, with those experiencing more serious injuries assumed to take longer to return to play. This means that these personality factors are influential in return to play behaviors, regardless of injury severity. The length of time it takes an individual to return to play is clearly highly varied, independent of injury severity, and influenced by sensation seeking and conscientiousness personality traits. Although there were no significant findings for impulsivity, extraversion, openness to experience, or neuroticism, all other predictions for return to play were supported.

History of both diagnosed and undiagnosed concussion was associated with higher levels of risk seeking, extraversion, and motor impulsivity. High levels of extraversion, typically implicated in risky sports behaviors, likely leads one to continue being involved with activities after experiencing a sports-related concussion as a result of a desire to maintain stimulation and social contact. Those high in risk seeking and motor impulsivity partake in risky actions for differing reasons. Those high in risk seeking likely find risky behaviors in sport more appealing – these behaviors could include more big picture risky behaviors like continuing to play following a sports-related concussion and could also include risky behaviors such as increased collision during sports participation. The degree to which those high in risk seeking have greater odds of sustaining diagnosed and undiagnosed sports-related concussions is likely due to the increased likelihood of partaking in these risky behaviors. Conversely, those high in motor impulsivity tend to take actions without thinking. As a result, the degree to which those high in motor impulsivity are more likely to sustain diagnosed and undiagnosed concussions is likely due to a tendency to take risky actions in the moment without considering the consequences. Risk seeking represents more forethought in concussion-related risky behaviors, while motor impulsivity represents more momentary action without consideration. Agreeableness was found to be significantly associated with a lower likelihood of incurring undiagnosed and diagnosed sports-related concussions. Those high in agreeableness tend to be cooperative and considerate, likely resulting in less aggressive or risky actions taken while participating in sport. This personality trait may also be related to a greater consideration for the precautions taken while participating in sport, thus resulting in fewer sports-related concussions.

While likelihood of both diagnosed and undiagnosed concussion were shown to be predicted by several of the same personality constructs, the likelihood of these injuries was also predicted by different personality constructs as well. For example, conscientiousness was found to be predictive of a greater likelihood of experiencing diagnosed concussion, while also predictive of a lower likelihood of experiencing undiagnosed concussion. This discrepancy highlights the degree to which these analyses represent the likelihood of experiencing these injuries and also the likelihood of reporting these injuries – both to a medical professional at the time of injury and honesty in reporting during the current study. This finding for conscientiousness likely indicates that those high in conscientiousness are more likely to report sports-related concussion and, as a result, likely both experience and report more diagnosed than undiagnosed sports-related concussions. Neuroticism and experience seeking showed the same pattern. Both of these personality constructs were predictive of an increased likelihood of diagnosed concussion and decreased likelihood of undiagnosed concussion. For those high in experience seeking, reporting sports-related concussion and seeking treatment (diagnosed concussion) as opposed to not reporting symptoms and seeking treatment (undiagnosed concussion) highlights the degree to which those who are high in this dimension prefer novelty and stimulation, but not necessarily risk. For those high in neuroticism, increased worry and guilt may be contributing to increased likelihood of reporting concussion (Lagunen, 2001; Lommen et al., 2010). Further, attentional impulsivity was found to be predictive of the likelihood of sustaining undiagnosed concussion, but not diagnosed concussion. Those who are high in attentional impulsivity tend to not be able to sustain focus or attention on the task at hand. This tendency may lead these individuals to experience less ability to dodge hits to the head, and thus they may experience more overall hits to the head while not necessary feeling the need to pursue treatment for these injuries.

Risk seeking, extraversion, and motor impulsivity were also found to be predictive of the likelihood of sustaining 2 or more concussions as opposed to 1, while agreeableness was found to be associated with a decreased likelihood of sustaining multiple sports-related concussions. The consistency in results between diagnosed concussion and likelihood of sustaining more than 1 concussion likely speaks to the degree to which those who report concussions (diagnosed) are also likely to be aware of the number of concussions they have sustained as well as be honest about reporting the true number of concussion they have experienced. Overall, risk seeking, extraversion, and motor impulsivity show the strongest relation with the likelihood of sustaining diagnosed concussion, undiagnosed concussions, and more than 1 concussion overall, while agreeableness is predictive of decreased likelihood of experiencing either type of concussion and likelihood of experiencing more than 1 sports-related concussion. Further, all 3 sub-constructs of impulsivity are predictive of a greater number of sports-related concussions, indicating that as the number of reported concussions increases, so does the role of self-report impulsivity. All predictions for likelihood of sustaining more than 1 concussion were supported.

As predicted, the majority of personality constructs that were more predictive of risky outcomes like early return to play and likelihood of concussion, were predictive of less use of protective behavioral strategies. Both when the effect of personality on protective behavioral strategy use was investigated for differences between high and low strategy use groups and when this effect was investigated at all levels of strategy use, experience seeking, risk seeking, attentional impulsivity, non-planning impulsivity, and motor impulsivity were all predictive of less strategy use. For those high in experience seeking and risk seeking, the use of strategies to keep oneself safe are likely viewed as both less novel and exciting, and less risky. As a result, these individuals participate in these strategies less overall. As a result of the protective behavioral strategies targeting behaviors before, during, and after sports participation, the sub-constructs of impulsivity likely played a unique role in protective behavioral strategy endorsement. For example, those high in non-planning impulsivity tend to not use forethought or planning which could likely result in participating in less behaviors like wearing protective gear and implementing safety strategies before play (Stanford et al., 2009). Additionally, those high in motor impulsivity and attentional impulsivity likely did not take proper precautions in the moment while playing. These relations between personality and specific protective behavioral strategies should be investigated in future research.

Conscientiousness, agreeableness, and neuroticism were found to be associated with increased use of protective behavioral strategies. As previously stated, individuals high in conscientiousness and agreeableness tend to be more compliant with rules and recommendations (Poropat, 2009). Those high in neuroticism likely experienced more worry and guilt around protective behavioral strategy use and thus participated in strategy use to a greater degree (Lagunen, 2001; Lommen et al., 2011). Overall, predictions for protective behavioral strategy use were supported. It was predicted that sensation seeking would be predictive of a greater likelihood of using protective behavioral strategies, while also being predictive of using less of these strategies overall. This hypothesis was not supported; however, all other predictions were supported.

Across hypotheses, risk seeking emerged as a significant predictor of all risky outcomes including early return to play, likelihood of both diagnosed and undiagnosed concussion, likelihood of more than 1 concussion, and use of fewer protective behavioral strategies. Experience seeking also emerged as a significant predictor of all of these outcomes except for likelihood of experiencing an undiagnosed concussion and likelihood of reporting more than 1 concussion. These results support previous research that has found that sensation seeking is positively associated with risky sports behavior more broadly (Bouter et al., 1988; Diehm & Armatas, 2004; Cherpitel et al., 1998; Turner et al., 2004), and sports-related concussion more specifically (Beidler et al., 2017a; Webbe & Ochs, 2007). The current study also supports the idea that risk seeking and experience seeking are distinct constructs with differing implications regarding sports-related concussion behaviors. These results regarding sensation seeking add to the existing body of literature about how this personality construct is associated with return to play behaviors and protective behavioral strategy use. These results replicate previous findings that have shown that sensation seeking is predictive of increased likelihood of undiagnosed concussion (Beidler et al., 2017a). The current study found, unlike previous studies, that sensation seeking is also predictive of likelihood of experiencing a diagnosed concussion.

Findings for self-report impulsivity in this study are in line with previous research in the significant positive association between self-report impulsivity and risky sports behaviors (Beidler et al., 2017a; Bouter et al., 1988). When the BIS-11 was used to assess for relations between impulsivity and likelihood of concussion, significant results were found for the BIS-11 total score such that the total score was significantly and positively associated with the likelihood of sustaining 2 concussions as compared to 1, and he likelihood of sustaining 1 concussion as compared to 0. (Beidler et al., 2017a). The current study replicates these findings and expands upon them in establishing the differential effects of sub-constructs of impulsivity on this outcome. While the interpretation of findings from the BIS-11 total score is supported, the multidimensional nature and previously stated broad application of this construct warrant investigation into more specific impulsivity predictors of health risk outcomes. The current study establishes motor impulsivity as the strongest predictor of risky behavior in the context of sport-related concussion. Overall there is not a clear delineation between the effects of impulsivity and sensation seeking in this study, but it is clear that the nature of the relations between these constructs and concussion-related outcomes is different, which supports emerging literature on the difference between the 2 constructs (Belin et al., 2008; Cyders et al., 2009; Dick et al., 2010; Smith et al., 2007, Steinberg, 2008).

The personality predictors most commonly investigated in risky sport behavior as well as specifically related to sports-related concussion are the Big Five factors of personality. The results from this study fall in line with expected results from previous research that established the positive association between extraversion and to a lesser extent openness to experience as positive predictors of risky sports behaviors (Castanier et al., 2010, Lee & Tseng, 2015; Tok, 2011), and conscientiousness and agreeableness as negative predictors of such behaviors (Beidler et al., 2017b, Castanier et al., 2010; Lee & Tseng, 2015; Nicholson et al., 2005; Tok, 2011; Vollrath et al., 2003). In general, conscientiousness has been linked to greater adherence to treatment protocol (Beidler et al., 2017) and low levels of conscientiousness have been linked to risky sports behaviors in general (Castanier et al., 2010; Lee & Tseng, 2015; Nicholson et al., 2005; Tok, 2011; Vollrath et al., 2003). Previous literature has shown a mixed role for neuroticism in risky sports behaviors (Beidler et al., 2017b, Merritt & Tharp, 2013, Vollrath et al., 2013). The current study provides evidence of the protective effects of neuroticism in the context of sports-related concussion. Recent work on the effects of the Big Five on likelihood of sustaining a concussion resulted in a positive relation between agreeableness and undiagnosed sports-related concussion (Beidler et al., 2017b). The authors of this previous study interpreted these findings as lower levels of agreeableness predicting a decreased likelihood of *reporting* an undiagnosed concussion. As a result, these authors concluded that low levels of agreeableness may be related to a higher likelihood of falsely reporting undiagnosed concussion. While this interpretation is plausible in light of previous research and theory, the current study found different results. Agreeableness is found to be associated with less risky behaviors across hypotheses including likelihood of experiencing both diagnosed and undiagnosed concussion, as well as an increased likelihood of participating in protective behavioral strategies.

As previously stated, self-report measures of impulsivity and behavioral measures of impulsivity tend to be minimally correlated with one another (Dick et al., 2010, Dougherty et al., 2005, Reynolds et al., 2006). Further, different measures of behavioral impulsivity have also been found to vary quite widely in their results, illustrating that different measures of impulsivity broadly may be tapping into differential components of the broader impulsivity construct (Reynolds et al., 2006). Minimal correlations between self-report and behavioral impulsivity measures were also found in this study. In general, results from behavioral impulsivity predictors varied. Unexpectedly, a few small effects were found for inhibition of initiated response such that more ability to inhibit was associated with an increased risk of early returning to play, increased likelihood of reporting a diagnosed concussion, and less protective behavioral strategy use overall. Mean time estimation, interpreted as the higher mean estimation of a minute the lower on the impulsivity construct one falls, was unexpectedly associated with an increased likelihood of reporting an undiagnosed concussion, a greater likelihood of reporting 2 or more concussions, as well as a greater likelihood of using protective behavioral strategies at higher meant time estimation. Expected results include higher levels of mean time estimation being associated with a lower likelihood of reporting a diagnosed concussion, as well as higher inhibition of an initiated response being associated with a lower likelihood of reporting more than 1 sports-related concussion. These results fall in line with previous research in that results of behavioral impulsivity measures differ greatly between different measures and different outcomes. However, both of these variables were at least moderately skewed and moderately kurtotic. The mean time estimation variable was very negatively skewed (-1.92) and very leptokurtic (9.22). The percent inhibited variable was moderately positively skewed (0.56) and platykurtic (2.22). This could have influenced the results.

It has been established that premature return to play is linked to an increased chance of experiencing repeat sports-related concussions (McCrea et al., 2009). Khurana and Kaye (2012) underscore the importance of following suggested return to play protocol to prevent this outcome. These researchers also mention that the ultimate decision to quit a sport and never return to play is an entirely individualized process in which there is no clear evidence-based advice. Further, past research has established that history of concussion is an important risk factor in sustaining more concussions (Schatz et al., 2011). Related work highlights the effects of multiple concussion by establishing the link between multiple concussions and long-term and adverse consequences for health (Edwards & Bodle, 2014; Khurana & Kaye, 2012, McCrea et al., 2009). Previous work has established the importance of these factors and the potential outcomes, and the current study adds to these findings by underscoring the idea that personality and individual difference level factors play a role in these outcomes. The findings from the current study demonstrate that current research and applied interventions for sports-related concussion prevention are largely missing an important piece of the puzzle: individual differences.

As a result of the clear link between personality and sports-related concussion risk and protective factors, personality measures should be incorporated into targeted prevention and intervention efforts for athletes. Most athletes are made to undergo preseason screening measures and physicals that establish a baseline of functioning in many ways. Incorporating self-report personality measures into these procedures would allow for more informed approaches to safety and injury prevention.

Limitations and Future Directions

Psychosocial factors, including psychiatric and psychological disorders, as well as environmental factors are known to play an influential role in risk taking in sport (Belley-Ranger et al., 2016; Hanson et al., 1992; Ivarsson et al., 2017), concussion recovery and rehabilitation (O'Jile et al., 2004; Yuen et al., 2016), and return to play (Asken et al., 2016; Khurana & Kaye, 2012; Kimbler et al., 2011). Within this study, some questions were asked regarding pressure to keep playing and coach presence, and a few protective behavioral questions focus on the environment. For the most part, this study focuses solely on personality as a predictor of post-injury behavior and subsequent injury. However, it is important to recognize the other factors that likely contribute to these outcomes of interest.

A body of research exists detailing changes in impulsivity following traumatic brain injury (Kocka & Gagnon, 2014; Rochat et al., 2010; Votruba et al., 2008). These changes are investigated at the personality level, as well as in terms of alterations in inhibitory control. As a result of this research, it is evident that traumatic brain injury, and concussion specifically, is related to some change in certain dimensions of impulsivity. For the purposes of this study, whether impulsive behavior results from the injury, or is a premorbid characteristic, was not differentiated. The purpose of the study was to investigate the effects of personality on post-injury risk-taking behavior, regardless of the cause or source of the personality/behavioral characteristics.

It has been noted in previous research, that behavioral and self-report measures of impulsivity are not highly correlated and may be measuring different components of the construct of impulsivity (Dougherty et al., 2005; Reynolds et al., 2006). This study also found that the particular behavioral impulsivity measures utilized in this study did not correlate strongly with the BIS-11. However, this should be noted as a potential limitation as both the self-report and the behavioral impulsivity measures utilized in this study are interpreted within the broad framework of impulsivity. Caution should be taken in interpreting behavioral and self-report measures because previous research states the likelihood that these types of measures are likely assessing completely different components of impulsivity (Dick et al., 2010, Dougherty et al., 2005, Reynolds et al., 2006). Future research should continue to investigate the differential associations of behavioral and self-report measures of impulsivity on sports-related injury outcomes.

While scales have been created and progressively validated for protective behavioral strategies with regards to alcohol use (Martens et al., 2005) and marijuana use (Pedersen et al., 2016), this concept has not been formally introduced to injury, specifically concussion. Because of this, the items included with regards to preventative, protective, and harm reduction strategies and behaviors in this study are derived from subject matter experts, previous studies, protocol, and modified from substance use items (Abrahams et al., 2014; Benson et al., 2013; Danseshvar et al., 2011; Emery et al., 2017; Hanson et al., 2014; Harmon et al., 2013; Martens et al., 2005; Noble & Hesdorffer, 2013; Patricios et al., 2018; Pedersen et al., 2016).

There was some ambiguity in determining the factor structure through exploratory factor analysis in the current study. The development of the Protective Behavioral Strategies scale for harm reduction strategies associated with cannabis use found a similar pattern of results wherein a 3 or 4 factor structure provided the most optimal fit but included a high number of cross loadings (Pedersen et al., 2016). The development of this cannabis use scale ultimately determined a 1 factor solution was the best solution for the data as a result of stronger factor loadings for a 1 factor solution and increased interpretability. The similarities in the cannabis Protective Behavioral Strategies scale and the current scale speak to a similar underlying nature that may be common in protective strategies scales in a variety of areas. Future work should continue to pursue formal scale development in the area of protective strategies for sports-related concussion. Future work should include utilizing this scale and protective behavioral strategy use in general to investigate the role of these strategies in concussion risk.

Additionally, due to the self-report and retrospective nature of the survey, concussion information may be inaccurately reported. Due to questions regarding past experiences and events, misreporting is possible. Individuals may also either over- or under-report their injuries for a variety of reasons. Previous studies have shown that those low in agreeableness were significantly less likely to report undiagnosed concussions and current concussion symptoms (Beidler et al., 2017b; Merritt et al., 2015). For current athletes, the fear of losing the chance to play from their symptoms coming to light, or the lack of self awareness that they are having concussion symptoms can lead to underreporting of concussion-related events and symptoms (Asken et al., 2016; Khurana & Kaye, 2012; Kimbler et al., 2011). Specifically, time to return to play was self-reported with participants estimating either days, weeks, or months between time of injury and return to play, for injuries occurring as much as 5 years ago. It is important to underscore the effects that personality results found in this study may reflect the tendency to both have experienced these occurrences and behaviors, as well as their tendency to *report* these occurrences and behaviors. This field would benefit from continued investigation of these research questions utilizing a longitudinal study design. A longitudinal study design may allow for greater accuracy in reporting as it pertains to memory in particular.

It is known that survival analysis is most optimally conducted and gives and the most accurate results when time to the event of interest is measured in the most precise metric of time possible. A limitation of the current study is that, with retrospective reporting, accuracy of reporting for injuries several years in the past is even more challenging when participants are asked to recall how long it took them to return to play in days or hours. As previously mention, longitudinal study design in future work may allow for more accuracy in return to play reports and may rely less on self-report. Verification of participant reports may be possible if collecting this data in real time.

Further, this study surveyed a sample of undergraduate students that were mostly of European descent; for this reason, these results may only be generalizable to samples containing individuals with similar demographic characteristics. Conducting this study with additional samples of young adults would create more generalizable findings. Future work should focus specifically on the ways that these phenomena may be present in younger cohorts of athletes. As is the case with many health risk behaviors, early intervention regarding healthy habits and prevention efforts may greatly decrease injury risk in the future.

Future Directions and Implications

Future work should aim to incorporate a longitudinal study design to eliminate the limitations of retrospective reporting and self-report. It would be beneficial for a future study to longitudinally investigate return to play such that athletes are followed over a span of years to document incidence of concussion and number of days to return to play. This study design, as previously mentioned, would allow for more precision in time to return to play which would allow for more concrete statistical conclusions. This type of study may incorporate an ecological momentary analysis (EMA) component wherein athletes are contacted regularly to assess for "hits to the head" during practices and games as well as subsequent symptoms. Such a study design would allow for a better metric of undiagnosed concussions than relying on self-report.

A future study should also include additional investigation into protective behavioral strategies in this domain. The current study demonstrated that these items likely form a single factor scale, but additional data collection and Confirmatory Factor Analysis will shed more light onto the underlying factor structure in these items. It would be beneficial to assess for the degree to which these strategies are used differentially between groups of individuals who have experienced a concussion and those who have not. The current study established that there was a significant different in overall strategy use between those who have and those who have not experienced a concussion, although sample size for those who have not experienced a concussion was small. Future work should include analyses that investigate the extent to which the use of these strategies is predictive of sustaining a sports-related concussion.

Finally, future work should implement an intervention wherein athletes scoring higher on measures of experience seeking, risk seeking, and self-report impulsivity are provided with individually tailored information about proper return to play protocol and the benefits of prevention strategy use. This intervention could also be used to monitor those who are high in these personality dimensions throughout their experiences of sports-related concussion and recovery. For example, if someone who falls at the higher range of the sensation seeking dimensions experiences a sports-related concussion, an extra symptom check may be put in place prior to return to play per research evidence that those with these personality traits tend to return to play quicker than other individuals.

This future work would also benefit from incorporating latent profile analysis to better determine what combinations of personality and individual difference level factors work together to contribute to the highest amount of risk in these areas. As a result, this work may progress to classifying athletes pre-season into categories, each with an associated risk of certain outcomes related to sports-related concussion. This type of classification could even more precisely identify which athletes are most at risk of certain risky behaviors in this domain, thus allowing increasingly individualized intervention. Future work may also choose to incorporate these principles and concepts with other types of sports-related injuries outside of sports-related concussion.

Lastly, this work would be most beneficial if it was done with a variety of athletes with a variety of identities. Stemming from literature in this area regarding the degree to which the accumulation of concussion and sub-concussive hits to the head can lead to long-term adverse outcomes, investigating the ways that personality can be used to prevent sports-related concussion at a variety of ages and competition levels could potentially prevent harmful habits and patterns from developing at young ages. This would may also investigate the ways that personality and cultural factors interact to contribute to risky behavior related to sports-related concussion.

Though there is still much work to be done in this area, results from this study highlight the importance of considering personality factors as influential predictors of risky behaviors related to sports-related concussion. Current efforts to understand the risk factors, protective factors, and related outcomes of sports-related concussion are currently conceptualized and implemented at the group level. However, as some recent research and the findings of this study show, there are significant differences in the ways that specific individual difference level factors influence return to play behaviors, concussion risk, and use of protective behavioral strategies.

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APPENDIX

Table A1: Protective Behavioral Strategy Items

Item 1: I stop participating in an activity
Item 2: I avoid other physically risky activities
Item 3: I wear protective gear
Item 4: I participate in activities at a less competitive or intense level than before
Item 5: I avoid contact during participation in a sport or activity
Item 6: I participate less often than before
Item 7: I participate for shorter amounts of time than before
Item 8: I took time off before participating in the activity again
Item 9: I avoid social contexts where others may be participating in physically risky activities
Item 10: I take more breaks during participation
Item 11: I establish a symptom limit at which I would stop playing and seek help
Item 12: I establish a number of hits or level of contact at which I would stop playing
Item 13: I change who I participate with
Item 14: I evaluate how I feel before I participate each time
Item 15: I find new friends outside the sport/create a support network outside the sport
Item 16: I choose a friend to help me identify concussion-related symptoms while participating
Item 17: I continue to educate myself on concussion symptoms, signs, and protocol
Item 18: I participate in cognitive rest to reduce symptoms
Item 19: I participate in balance and strengthening exercises
Item 20: I participate in sub-symptom exercise (non-risky cardio)
Item 21: I follow all the doctor’s instructions for recovery
Item 22: I avoid participation when I am not feeling like my ‘head is in the game’

Table A2: Cumulative Proportion Hazard Model Relative Risk

	b	RR	CI	SE	p
Experience Seeking	0.063	1.065	[1.018 - 1.114]	0.023	.01*
Risk Seeking	0.036	1.037	[1.005 - 1.070]	0.016	.02*
Attentional Impulsivity	0.019	1.020	[0.991 - 1.047]	0.014	.18
Motor Impulsivity	0.014	1.014	[0.989 - 1.040]	0.013	.27
Non-planning Impulsivity	0.017	1.017	[0.993 - 1.041]	0.012	.16
Openness to Experience	0.052	1.054	[0.997 - 1.113]	0.028	.06
Conscientiousness	-0.053	0.949	[0.903 - 0.996]	0.025	.03*
Extraversion	0.018	1.018	[0.979 - 1.059]	0.020	.36
Agreeableness	0.013	1.014	[0.961 - 1.068]	0.027	.62
Neuroticism	0.014	1.014	[0.973 - 1.057]	0.021	.51
Mean Time Estimation	0.007	1.007	[0.991 - 1.023]	0.008	.41
Percent Inhibited	0.004	1.004	[1.000 - 1.008]	0.002	.04*

Note: * indicates significant results at the .05 significance level

Table A3: History of Sports-Related Concussion

	b	OR	CI	SE	p
Experience Seeking	0.085	1.089	[1.078 - 1.101]	0.005	<.001*
Risk Seeking	0.064	1.066	[1.059 - 1.074]	0.004	<.001*
Attentional Impulsivity	0.002	1.002	[0.996 - 1.009]	0.003	0.47
Motor Impulsivity	0.046	1.047	[1.040 - 1.054]	0.003	<.001*
Non-planning Impulsivity	0.023	1.023	[1.017 - 1.029]	0.003	<.001*
Openness to Experience	0.035	1.036	[1.022 - 1.050]	0.007	<.001*
Conscientiousness	0.023	1.023	[1.012 - 1.035]	0.006	<.001*
Extraversion	0.095	1.099	[1.089 - 1.110]	0.004	<.001*
Agreeableness	-0.058	0.943	[0.931 - 0.956]	0.007	<.001*
Neuroticism	0.068	1.070	[1.060 - 1.081]	0.005	<.001*
Mean Time Estimation	-0.009	0.991	[0.988 - 0.994]	0.002	<.001*
Percent Inhibited	0.001	1.001	[1.000 - 1.002]	0.0005	.04*

Note: * indicates significant results at the .05 significance level

Table A4: History of Undiagnosed Sports-Related Concussion

	b	OR	CI	SE	p
Experience Seeking	-0.030	0.970	[0.954 - 0.987]	0.009	<.001*
Risk Seeking	0.067	1.069	[1.056 - 1.083]	0.006	<.001*
Attentional Impulsivity	0.045	1.046	[1.034 - 1.058]	0.006	<.001*
Motor Impulsivity	0.029	1.029	[1.018 - 1.041]	0.006	<.001*
Non-planning Impulsivity	0.002	1.002	[0.992 - 1.012]	0.005	.73
Openness to Experience	0.007	1.007	[0.983 - 1.030]	0.012	.56
Conscientiousness	-0.039	0.962	[0.944 - 0.980]	0.010	<.001*
Extraversion	0.019	1.019	[1.003 - 1.035]	0.008	.02*
Agreeableness	-0.105	0.900	[0.880 - 0.920]	0.011	<.001*
Neuroticism	0.064	0.933	[0.923 - 0.953]	0.008	<.001*
Mean Time Estimation	0.017	1.017	[1.012 - 1.022]	0.003	<.001*
Percent Inhibited	0.003	1.003	[1.002 - 1.005]	0.001	.04*

Note: * indicates significant results at the .05 significance level

Table A5: History of 2 or More Sports-Related Concussions

	b	OR	CI	SE	p
Experience Seeking	0.012	1.012	[0.997 - 1.028]	0.005	.11
Risk Seeking	0.072	1.075	[1.063 - 1.087]	0.006	<.001*
Attentional Impulsivity	0.053	1.055	[1.044 - 1.065]	0.005	<.001*
Motor Impulsivity	0.029	1.029	[1.019 - 1.039]	0.005	<.001*
Non-planning Impulsivity	0.009	1.009	[1.001 - 1.018]	0.004	.03*
Openness to Experience	-0.041	0.959	[0.941 - 0.979]	0.010	<.001*
Conscientiousness	-0.010	0.990	[0.973 - 1.006]	0.008	.21
Extraversion	0.033	1.034	[1.020 - 1.048]	0.007	<.001*
Agreeableness	-0.030	0.970	[0.952 - 0.989]	0.010	.002*
Neuroticism	0.024	1.025	[1.010 - 1.039]	0.007	<.001*
Mean Time Estimation	0.009	0.991	[1.005 - 1.014]	0.002	<.001*
Percent Inhibited	-0.009	0.990	[0.989 - 0.992]	0.001	<.001*

Note: * indicates significant results at the .05 significance level

Table A6: Protective Behavioral Strategy Use (>75th Percentile vs. < 50th Percentile)

	b	OR	CI	SE	p
Experience Seeking	-0.063	0.939	[0.929 - 0.950]	0.006	<.001*
Risk Seeking	-0.120	0.888	[0.881 - 0.896]	0.004	<.001*
Attentional Impulsivity	-0.077	0.972	[0.918 - 0.933]	0.004	<.001*
Motor Impulsivity	-0.084	0.918	[0.912 - 0.926]	0.004	<.001*
Non-planning Impulsivity	-0.095	0.909	[0.903 - 0.916]	0.004	<.001*
Openness to Experience	-0.014	0.986	[0.971 - 1.001]	0.008	.07
Conscientiousness	0.132	1.141	[1.126 - 1.157]	0.007	<.001*
Extraversion	-0.027	0.972	[0.963 - 0.982]	0.005	<.001*
Agreeableness	0.041	1.042	[1.027 - 1.057]	0.007	<.001*
Neuroticism	0.023	1.023	[1.012 - 1.033]	0.005	<.001*
Mean Time Estimation	-0.012	0.987	[0.984 - 0.991]	0.002	<.001*
Percent Inhibited	-0.006	0.993	[0.993 - 0.995]	0.001	<.001*

Note: * indicates significant results at the .05 significance level

Table A7: Protective Behavioral Strategy Use

	b	CI	SE	p
Experience Seeking	-1.062	[-1.364 - -0.760]	0.154	<.001*
Risk Seeking	-2.111	[-2.413 - -1.809]	0.103	<.001*
Attentional Impulsivity	-1.519	[-1.423 - -1.104]	0.103	<.001*
Motor Impulsivity	-1.418	[-1.346 - -1.036]	0.099	<.001*
Non-planning Impulsivity	-1.666	[-1.484 - -1.205]	0.089	<.001*
Openness to Experience	-0.824	[-1.203 - -0.564]	0.209	<.001*
Conscientiousness	2.202	[1.533 - 2.067]	0.171	<.001*
Extraversion	-0.493	[-0.731 - -0.314]	0.133	<.001*
Agreeableness	0.262	[-0.047 - 0.571]	0.158	.09
Neuroticism	2.034	[1.765 - 2.572]	0.137	<.001*
Mean Time Estimation	-0.186	[-0.216 - -0.056]	0.051	.001*
Percent Inhibited	-0.198	[-0.174 - -0.127]	0.015	<.001*

Note: * indicates significant results at the .05 significance level