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THE LONG-TERM BEHAVIORAL EFFECTS OF CONCUSSIONS AND POST-
CONCUSSION SYNDROME

by

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A Thesis Submitted in Partial Fulfillment
of the Requirements for a Degree with Honors
(Communication Sciences and Disorders)

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ABSTRACT

The focus of this thesis is to examine the effects of concussions on college athletes, specifically their social activity and behavioral changes. Concussions are mild traumatic brain injuries (mTBI) that occur after receiving a blow to the head or a whiplash injury that causes an altered state of consciousness, including but not limited to, being unconscious. The National Collegiate Athletic Association (NCAA) reports that in the past five years college athletes have suffered 10,500 concussions. Unlike professional athletes, who have the luxury of being able to rest until fully healed, college student athletes have the demands of academics often rushing them back to the classroom before they are healed completely. This demand can lead to prolonged symptoms. This thesis will explore how concussions can have lasting effects on behavior and academics, not just acute effects during the healing process.

The PROMIS-29 survey was conducted to study the behavioral and social aspects of Division I student athletes in five sports. The response rate was low, however the data that was collected was trending along with studies that have been conducted previously.

DEDICATION

I dedicate my thesis to my parents and sisters who have supported me through my athletic and academic career and were crucial in my own concussion recovery. I also would like to thank my class for their undying support in my academic and athletic career. Finally, I would like to thank my advisor, Ryan W. Taylor, for who without I could never have done this research.

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INTRODUCTION

Concussion is a mild traumatic brain injury caused by a blow or jolt to the head or hit to the body that rapidly moves the brain back and forth (Centers for Disease Control and Prevention, 2019). This injury impacts the chemical metabolic system of the brain and leads to a wide range of symptoms including headaches, dizziness, low energy, mental foginess, etc. The National Collegiate Athletic Association (NCAA) reports 10,500 concussions in its athletes in the last five years, with the top five concussion sports being football, men and women's ice hockey, women's soccer, and wrestling. While concussions are categorized as a type of traumatic brain injury, the seriousness of this injury is often not realized by the patient or the people around them. It is crucial to continue research on the short- and long-term effects of concussions so that treatment protocols can keep improving and there is more awareness surrounding this type of injury. The NCAA and U.S. Department of Defense joined forces in 2014 to conduct the largest concussion study to date in order to make student-athletes and service members safer. In the last 15 years, Chronic Traumatic Encephalopathy (CTE) was found to be caused by repetitive blows to the head and untreated concussions in contact sport athletes and servicemen and women. This discovery led to many protocol changes and improvements within sports regarding treatments and diagnosis as well as rule changes. However, a key distinction is that CTE is believed to be caused by concussions that went untreated; the research does not focus on effects in the brain after proper diagnosis and treatment protocols are followed.

In 2011, a class action concussion lawsuit was filed against the NCAA by former male and female NCAA collegiate athletes called the Arrington Matter. In November 2019, the Arrington Agreement was formalized, and changes were enacted at member schools, which include medical monitoring certification that certifies the school has a concussion management plan that meets the requirements of the Section I.X.A. of the settlement agreement, and concussion reporting to the NCAA. The settlement also guaranteed free medical screening and testing to student-athletes who had competed for an NCAA school on or prior to July 15, 2016 (NCAA, 2019). The goal of this settlement was to provide better concussion protocol and treatment for current and future student-athletes as well as provide free medical care for past student-athletes who suffered a concussion(s) and did not receive the proper care or heal completely (NCAA, 2019). A key aspect of the settlement that has been enacted in all member schools is the requirement to report annually all sports-related concussions and when they resolved. This reporting process began May 18, 2020, so all concussions that occurred on or after this date must be reported to the NCAA for member institutions to keep their certification (NCAA, 2019). An important distinction is that the settlement does not define “concussion resolution.” However, there is current return to play protocol that all athletics programs across collegiate and high school levels utilize, including the Impact test, symptom sheets, and steps to easing back into work outs. Even though these bodies employ the same protocols, the definition of “concussion resolution” leaves room for error because it does not consider post-concussion syndrome, migraines, or mental health issues that one might develop after having been considered cleared from their concussion. While this settlement case is an important start in the study and treatment of concussions,

there needs to be further research on the damage that concussions cause within the brain and how well that damage heals, if at all. It is also crucial to create a clear definition of “concussion resolution” that includes the possible comorbidities an individual could develop during and after concussion.

In this study, Division I student-athletes from men and women’s ice hockey, football, and women’s soccer participated in completing the PROMIS-29 survey to report all behavioral effects they have noticed since healing from a concussion(s). The field of concussions is still a relatively new subject and therefore the research on long-term effects, specifically on behavior and cognitive function, is lacking. This study aims to provide further research on the topic in the hopes that similar studies will be conducted in the future.

LITERATURE REVIEW

Introduction

Concussion is defined as a mild traumatic brain injury caused by a jolt or blow to the body or head. Over the past 50 years individual researchers, research groups, and international bodies have defined concussions; some definitions concur, and others do not (McCrory et al., 2017). These differences in definition make the identification and management of concussions difficult because there is no gold standard. There has also been some drive to define sports-related concussions (SRC) and non-sport related concussions differently due to different sport bodies wanting “clear and practical guidelines to determine recovery and safe return to play” (McCrory et al., 2017). However, whether it is a SRC or non-sports related concussion does not change that the injury is a mild traumatic brain injury.

Within recent years, studies have focused on the neuropathology of concussions and what changes take place in the brain. The immediate, acute changes following a trauma to the head that results in a concussion are seen in the glutamate and gamma aminobutyric acid (GABA) concentrations within the brain (Romeu-Mejia et al., 2019). Glutamate is the neurotransmitter that is present in over 90 percent of brain synapses and is responsible for typical brain function. Nerve cells utilize glutamate to send signals to other cells within the central nervous system. Any disruption in the levels of glutamate leads to brain dysfunction and can be detrimental. GABA is the main inhibitory neurotransmitter in the brain. GABA and glutamate work in tandem with one another. Glutamate is the excitatory neurotransmitter that sends signals to other cells in the

nervous system while GABA is the neurotransmitter that blocks signals to other cells within the nervous system. Maintaining this balance between glutamate and GABA is crucial to proper brain function. During a concussion this balance is disrupted causing brain dysfunction to occur. The concentrations of these neurotransmitters are “region-specific and time-dependent” (Romeu-Mejia et al., 2019). Recent findings have also seen that genetics may play a role in symptom severity and recovery, while gender differences seem to be correlated with neuroinflammatory response and neuroplasticity (Romeu-Mejia et al., 2019). Researchers found that girls and women experience a higher rate of concussion than their male counterparts in the same sports at both the high school and collegiate level (Romeu-Mejia et al., 2019). According to Romeu-Mejia et al. a more current definition of concussion is:

A brain injury induced by direct or indirect biomechanical force transmitted to the head, resulting in a reversible clinical syndrome manifested as signs and symptoms affecting the physical, cognitive, emotional, and sleep domains reflecting a predominantly functional, rather than structural injury.

However, it is believed that subconcussive impact causes the same neuronal damage without reaching the elusive “concussion threshold” which leads to the absence of symptoms following these impacts (Romeu-Mejia et al., 2019). A subconcussive impact, or subconcussive blow, is defined as an impact to the brain that results in neuronal and axonal damage while not producing clinical symptoms (Manley et al., 2017).

Short-term effects of concussions

Adame and Corman (2019) defined concussions as “injuries [that] pose threats to both short-term and long-term brain health.” Short-term effects of concussion injuries

include the likelihood of experiencing another concussion and musculoskeletal injuries (i.e. whiplash). Data collected by the NCAA indicates that each year there are 1.6-3.8 million concussions from participation in sports of all levels. It is highly possible that these numbers are an underestimate because athletes are likely to underreport/hide concussion symptoms from coaches, athletic trainers and team physicians. It has been proven that concussions can result in serious mental and physical problems such as depression, dementia, cognitive impairment, post-concussion syndrome and CTE. Recent research has found that out of 202 American-style former football players, 177 had CTE, about 87 percent (Adame & Corman, 2019).

One essential part of concussion diagnosis and treatment is communication from the athlete who has suffered an impact to the head. Honest communication is crucial in order to make the proper diagnosis and follow return to play protocol. Without this communication, it is much more difficult to make the diagnosis or follow the protocol, which can in turn lead to short- and long-term effects for the athlete in the future.

Short-term effects of concussions that are not related to anatomy or chemical balances in the brain include fear of being replaced and the fear of being perceived as “soft” by teammates and coaches. Many athletes with concussions have reported that the fear of losing playing time due to their injury or not playing at all often prohibits them from reporting the injury (Adame & Corman, 2019). Athletes have also reported that the perception of being seen as weak or soft prevents them from communicating with medical personnel about their injury (Adame & Corman, 2019). These fears, especially if left unaddressed, can lead to further injury as well as anatomical and behavioral long-term effects.

Adame and Corman provide a strong foundation for the reporting behaviors of athletes with concussions. The next step in the research is to study the general behavior of a person before and after having suffered a concussion(s). There is no behavioral baseline testing, like the cognitive and physical baseline testing which athletes must complete in order to be eligible to compete.

Long-term effects of concussions

Long-term effects of concussion injuries include post-concussion syndrome and/or the development of chronic traumatic encephalopathy (CTE) as well as the development of mental health disorders and alterations in behavior (Adame & Corman, 2019).

Post-concussion syndrome is defined as concussion symptoms that last beyond the expected time of recovery (weeks to a few months) and included headaches, dizziness, attention and memory problems (Mayo Clinic, 2021). The severity of the initial injury does not have any correlation with the development of post-concussive symptoms. Medical experts believe that post-concussion syndrome can be a result of structural damage to the neurons after the initial impact and a result of psychological factors (Mayo Clinic, 2021). Two risk factors have been identified with the development of post-concussion syndrome: age and sex. The older a person is the more likely they are to develop post-concussion syndrome. Also, women are more likely to develop post-concussion syndrome, however this could be because women are more likely to seek medical attention (Mayo Clinic, 2021).

Research indicates that there are some parallels in long-term psychosocial outcomes between mild traumatic brain injury (mTBI) and minor strokes (Verberne et al., 2021). The researchers focused on anxiety and depression symptoms at 6 weeks, 3-, 6-, and 12-months post-injury (stroke or mTBI). At 12 months, effects had stabilized for both groups; participants with minor strokes reported a significantly higher finding in anxiety symptoms than participants with mTBI (Verberne et al., 2021). However, patients with mTBI and patients with strokes reported similar scores regarding depression symptoms (Verberne et al., 2021). These findings indicate the importance of paying attention to anxiety and depression symptoms, and cognitive issues in daily life because these require aftercare.

While strokes and mTBIs are of different pathophysiological processes, they become increasingly similar in the long-term regarding deficits and course of treatment. Often mTBI patients are told to rest and recover and not offered long-term treatment due to the idea that they will be able to return to daily normal life with the expectation of full functioning recovery. However, 20-25 percent of those patients develop persisting psychosocial symptoms (emotional and cognitive problems) (Verberne et al., 2021). Six months following the initial injury, brain recovery typically stabilizes and so any problems left untreated can persist into the long-term. Anxiety persists in 23 percent of mTBI cases and depression persists in 16 percent of mTBI cases. In around 50 percent of mTBI cases, cognitive deficits persist into the long term. This study found that it is important to monitor psychosocial symptoms because they are not easily identifiable, but impact everyday life.

This research was not conducted on student-athletes. The mean age range was 57-65 years of age. It is important to note that neuroplasticity at this age is far less than in student-athletes who are typically 18-25 years of age. The brain does not fully develop until 25 years of age, therefore collegiate student-athletes' brains are not fully developed and have more neuroplasticity which could help them heal better following an mTBI. Further research is needed to identify the long-term effects of mTBIs in athletes, particularly college athletes whose brains are not fully developed during the time of injury.

Manley et al. (2017) examined the possible long-term effects of sports-related concussions on retired former athletes. The researchers also examined the impact that repeated subconcussive blows over the course of an athlete's career can have later in the athlete's life. Subconcussive blows or subconcussive impacts are defined as "involving the transfer of mechanical energy to the brain at enough force to injure axonal or neuronal integrity, but not be expressed in clinical symptoms" (Manley et al., 2017). Researchers reviewed 3, 819 studies, 47 of which met the inclusion criteria. Long-term was defined as greater than or equal to 10 years post-injury.

It was found that some former athletes suffer from depression and cognitive deficits later in life, with an association between these deficits and a multitude of concussions. The neuroimaging studies that were reviewed demonstrated that there is some evidence of "macrostructural, microstructural, functional and neurochemical changes in some athletes" (Manley et al., 2017). It was also found that retired athletes of an older age who had at least one loss of consciousness (LOC) due to concussion had significantly smaller bilateral "hippocampal volumes and decreased memory

performance” (Manley et al., 2017). The researchers also studied 37 amateur soccer players. They found that a lifetime concussion history was not associated with changes in cognitive performance, however high-frequency of heading the ball (>885 per year) was associated with lower memory scores and lower fractional anisotropy in the temporo-occipital white matter (Manley et al., 2017). This means that these athletes have a lower fiber density, axonal diameter and myelination in their white matter than the typical brain. It was also found that 797 former collegiate players, 39% with a concussion history, self-reported their mental health/cognitive problems as “depression=10.4%, anxiety=16.2%, alcohol dependence=5.8%, substance use=2.9%, and cognitive problems=3.8%” (Manley et al., 2017). While there was not corresponding data for non-athletes with a concussion history there was data on depression symptoms for former NFL players and corresponding men of the same age and intelligence quotient (IQ). Manley et al. states that cognitively intact former NFL players reported a greater prevalence of depression symptoms than men the same age with the same IQ (2017).

Researchers concluded that multiple concussions appear to be a risk factor for developing cognitive impairments and mental health problems. As of right now the relationship between length of career, heading the ball, cognitive function and psychological health is still unclear. There needs to be more research conducted in order to determine the extent to which concussions and subconcussive impacts are related to the development of these cognitive deficits and mental health problems as well as the prevalence of CTE.

Factors that make an athlete more likely to report and less likely to report

There are many factors associated with the likelihood of an athlete reporting a concussion. Clark and Stanfill (2019) found, after a systematic review of many studies, that female athletes and younger-aged athletes make a participant more likely to report a sports-related concussion. Factors that made it less likely for a participant to report a SRC are the loss of playing time, fear of letting the team down, belief that concussive injury is not serious, and lack of knowledge of the signs and symptoms of a concussion (Clark & Stanfill, 2019). Even though there is legislation in place to protect high school and collegiate athletes from returning to play too soon and educating the athletes and coaches on concussion protocol, concussions are still going underreported across all levels of sport (Clark & Stanfill, 2019). This lack of reporting is partially due to the fact that many of these new mandates emphasize the symptoms of concussion but not the risks associated with returning to play too soon, or not taking the symptoms seriously. It has also been found that even with the knowledge of the dangers of not reporting a concussion, there is still an underreporting issue (Clark & Stanfill, 2019). The presence of an athletic trainer also increases the chance of reporting a concussion due to the lack of pressure they present in returning to play. A major takeaway from this review is that education about concussions should not just focus on the athlete, but all those involved in the sport (athlete, teammate, coaches, fans, parents, etc.)

Education surrounding concussions

The current education system in place for concussions is one that is solely based on symptom recognition and in turn neglects all other consequences of concussions such

as behavior, mental health and physical health. According to Ramsay and Dahinten better education on the dangers of concussions could lead to reduced numbers of concussion and level of severity in youth sports and counter the underreporting problem (2020). The education of youth sports participants could provide them with better knowledge and understanding of the seriousness of concussions as they mature and continue to participate in higher levels of sports. Ramsay and Dahinten state:

increased knowledge about the symptoms of concussion, potential long-term consequences, and heightened risk for a second concussion during a period of vulnerability following concussion may contribute to increased reporting and adherence to return to play (RTP) protocols (Norton et al., 2013).

While beginning education of the symptoms and seriousness of concussions in youth sports is important for establishing a baseline of understanding for athletes, parents and coaches, it is also imperative that this education continues throughout an athlete's career. Many education programs in the past consisted of health care professionals presenting videos, statistics and sheets to groups of student-athletes (Earnst & Kneavel, 2020). These programs have been shown to increase concussion knowledge, however there has been little evidence to indicate that this increase in knowledge has led to more athletes to self-report their concussion (Earnst & Kneavel, 2020). The key piece missing from current concussion education is the facilitation of a change in attitude regarding reporting behavior and creating a different culture of safety within sports. Earnst and Kneavel designed a peer concussion-education program (PCEP) in order to address this missing piece in concussion education. The goal is to change "team norms to be more conducive to concussion safety" and was advised by the Theory of Reasoned Action and Planned Behavior (TRA-TPB). This theory has been used to understand attitudes and norms related to different health behaviors and states that knowledge of a health issue is only a

predictor of behavior if the norms and group behavior support the behavior (Earnst & Kneavel, 2020). If the education about concussions is coming from peers it is believed that athletes will be more likely to report. This hypothesis is further supported by an anonymous survey that concluded only about 10% of athletes would be unlikely or extremely unlikely to conceal a concussion from teammates (Earnst & Kneavel, 2020). One important aspect of the PCEP is that it is designed to be used in conjunction with the current concussion education system in order to enhance it rather than replace it. It is still crucial to be receiving all of the facts and statistics from healthcare professionals and then having the PCEP to provide the peer-to-peer connection. The PCEP program trains two student-athletes per team to become PCEs and have them “facilitate change in group norms in order to transform the culture of concussion from within the team,” (Earnst & Kneavel, 2020).

This type of programs inspires student-athletes to buy-in to the information they are receiving and to take their brain health more seriously because it is coming from the people who they are spending countless hours with day in and day out, who they respect, and in many cases consider their family. A PCEP also allows concussion reporting behavior and brain health to become a conversation within the team rather than just an injury that is talked about with the healthcare professionals.

Behavior/Mental Health

In many post-concussion surveys the athlete is asked to report their levels of irritability, sadness, anxiety, etc. following the injury. However, the athlete hardly ever has a baseline to compare their post-injury behavior/mental health results to therefore it

can be difficult to compare an athlete's typical behavior and mental health pre- and post-injury.

The Riegler et. al (2020) study found that depressed collegiate athletes performed significantly worse on Memory Composite, Brief Visuospatial Memory Test, and Hopkins Verbal Learning Test following concussion. These results indicate the importance of screening for depression post-concussion in order to gain a full picture view of the impairments an individual is facing as well as screening for depression, anxiety, and other mental health disorders when conducting baseline testing. This study does not determine that concussion causes depression, but rather that athletes who have suffered a concussion and have depression perform worse on other cognitive baseline tests. In order to see if this depression is caused by concussion there must be a comprehensive screening process that identifies if a student-athlete has depression or other behavioral/mental health disorders prior to injury.

METHODS

Institutional Review Board and Subject Recruitment

This research study was started by first receiving approval from the University of Maine Human Subjects Review Board. An application and proper documentation was submitted, reviewed, and edits were made and resubmitted. Approval for the research was given on November 17, 2020.

A list of universities in the America East, Colonial Athletic Association, and Hockey East conferences was created and upon approval emails were sent to each school with the survey attached. Follow-up emails were sent on December 20, 2020 to encourage more responses to the PROMIS-29 survey.

Transcription and Data Storage

At the completion of the survey, each respondent's answers were recorded and analyzed. The researcher used Qualtrics to collect data from respondents, so the information is anonymous and the researcher does not know the identity of the respondent. The researcher's computer is password protected and all folders containing research materials are password protected as well.

Data Analysis

Following completion of the PROMIS-29 survey, the answers were reviewed and coded for themes. The primary researcher then analyzed themes collected from the data as well

as from the in-depth literature review that was done in conjunction with the survey to draw conclusions on long-term behavioral effects of concussions. The primary researcher also took into account the effect that the COVID-19 pandemic could have on not only mental health, but overall response rate.

RESULTS

Participants

Participant schools were from the America East, Colonial Athletic Association, and Hockey East Conferences. They were selected via an email sent out in November by the primary investigator to the athletic trainers of the sports that were being studied: football, men and women's ice hockey, and women's soccer. All responses from all conferences chosen were accepted. A follow-up email was sent to the same athletic trainers in January. Participants were not asked to indicate what conference they belonged to when filling out the survey in order to maintain their privacy and anonymity. Participant responses were from the Division I student-athletes who completed the PROMIS-29 survey.

Honesty

Honesty is crucial in diagnosing and treating concussions. Honesty is also essential when attempting to study concussions and their effects on people. One critical component of the PROMIS-29 survey is the honesty of the participants. A participant can be dishonest for a variety of reasons. Athletes are taught from a young age that being honest about an injury is often what leads to missing games or practices and having to take time off. At the Division I level, the researcher has to be conscientious of the competitiveness and desire that athletes at this level have and realize that they may not always be gathering honest answers because the athlete wants to portray that they are healthy enough to compete.

By reviewing and analyzing the responses to this survey, it can be speculated that not all answers provided by athletes who are currently competing are honest. This could also be due to the fact that they do not want to admit to someone else (even though the survey is anonymous) or themselves that they are struggling with the aftermath of a concussion or concussions. Athletes are given the message that they cannot show signs of weakness if they want to succeed in their sport. Many athletes will align weakness with long-term effects of concussions because it is something that alters them and needs to be treated. Rather than admitting to these ailments, an athlete may hide them in order to hide their “weakness”.

PROMIS-29 Survey

The Patient-Reported Outcomes Measurement Information System-29 (PROMIS-29) is a short assessment that measures depression, anxiety, physical function, pain interference, fatigue, sleep disturbance, and ability to participate in social roles and activities. This survey is not exclusive to concussion research; however, it has been used recently to measure the behavioral and cognitive effects caused by concussion and subconcussive impacts on former professional and collegiate athletes. It is important to note that the PROMIS-29 survey has not been used to study the behavior, mental health, pain and physical function of current collegiate student-athletes.

There were 8 (n=8) responses to the survey, one response indicating no concussion history, one respondent who was unsure if they had had a concussion, and six responses indicating they had had at least one concussion. There were three responses from women’s soccer players, one response from an American-style football player, and

two responses from ice hockey players (men's or women's not indicated). After answering six questions, one of the women's soccer players did not continue the survey. The number of responses gathered for this survey was much less than anticipated. Despite follow-up emails, discussions with the athletic trainers at the University of Maine, and athletic trainers urging their student-athletes to participate in the survey, only 8 responses were collected. In other concussion research, having a sample size of around 15 to 20 is generally the norm. There are fewer studies done on concussions that have a large sample size, and these studies are usually completed by large organizations who have the resources to fund it over a period of years. These studies are also generally more in depth and combine a self-report questionnaire with in-depth interviews, sometimes multiple interviews, in order to fully understand the subjects. An extensive study like these was not possible in the seven and a half month time frame available for this research.

Questions 26-29 ask the participant about their anxiety and any feelings of uneasiness the participant may have had in the last seven days. The responses were as follows: question 26, 17% rarely felt fearful, 83% never felt fearful; question 27, 17% rarely had trouble focusing due to anxiety, 83% never had trouble concentrating due to anxiety; question 28, 33.33% rarely were overwhelmed by worry, 67% were never overwhelmed by worry; question 29, 33.33% sometimes felt uneasy, 17% rarely felt uneasy, and 49.7% never felt uneasy. Anxiety can be a crippling disorder if not treated and managed properly. Destigmatizing mental health is vital in the diagnosis and treatment of anxiety disorders. Student-athletes and professional athletes have long been told that they need to toughen up and get over it. This approach and long-standing culture in athletics has led many athletes to not ask for help, which could be a reason why there

was a low response rate, and of the responses symptoms of anxiety were not common in comparison to previously published literature. The previously published literature studied anxiety in former athletes and non-athlete participants who had suffered from a concussion and reported symptoms of anxiety.

Questions 30-33 ask the participant about depressive symptoms and whether they have felt depressed at all in the last seven days. The responses for these questions were as follows: question 30, 100% never felt worthless; question 31, 17% rarely felt helpless, 83% never felt helpless; question 32, 16% felt rarely depressed, 84% never felt depressed; question 33, 33% rarely felt hopeless, 67% never felt hopeless. Similarly to the response rate of questions that measured anxiety, participants may have been hesitant to disclose the severity of their depressive symptoms, which could have led to a skewed statistic of the prevalence of depression or depressive symptoms post-concussion. Furthermore, student-athletes talk amongst themselves and could have discussed receiving this survey and what types of questions were on it with teammates who may have also received the survey and not taken it yet. After hearing about the types of questions that were being asked and what data was being collected, they could have opted not to take it based on their self-stigma surrounding mental health and mental illness.

Questions 34-41 ask the participant about their irritability within the last seven days. The responses for these questions were more positive than the depressive symptoms questions, with more respondents indicating irritability. The responses are as follows: question 34, 17% rarely had trouble controlling their temper, 83% never had trouble controlling their temper; question 35, 17% rarely had trouble controlling their behavior, 83% never had trouble controlling their behavior; question 36, 20% sometimes said or

did something without thinking, 20% rarely said or did something without thinking, and 60% never said or did something without thinking (one respondent did not answer); question 37, 17% often got impatient with other people, 17% sometimes got impatient with other people, 17% rarely got impatient with others, and 51% never got impatient with others; question 38, 33.33% sometimes were irritable around others, 17% rarely were irritable around others, 51% were never irritable around others; question 39, 17% were often bothered by little things, 33.33% were sometimes bothered by little things, 17% were rarely bothered by little things, 33.33% were never bothered by little things; question 40, 33.33% were sometimes easily upset, 33.33% were rarely easily upset, 33.33% were never easily upset; question 41, 17% were sometimes in conflict with others and 83% were never in conflict with others.

All respondents indicated that they had a support system and someone to confide in if they had any of these feelings or were having a bad day. Respondents also indicated that every day activities were not impaired, and that sleep was not altered.

CONCLUSION

Concussions have been the center of research in collegiate athletics and professional athletics for decades. However, this research has mostly been done on the anatomy and chemistry of concussions rather than the long-term implications and behavioral consequences. Only in the last four years have researchers begun to study the potential long-term effects of concussions on NCAA athletes. This study is a starting point for research like this to continue in the future. This type of study allows for baseline testing to change and include a type of “mental health physical” that athletes complete every preseason. This could be done with a sports psychologist using a questionnaire like the Patient Health Questionnaire-9 (PHQ-9) to diagnose and measure depression, severity of depression and monitor the depressive symptoms. It could also be beneficial to conduct more concussion research on current student-athletes and professional athletes, rather than after their careers have ended. By doing so, researchers could attain a more well-rounded view of the person, rather than attempting to have the individual or family members report how they use to behave and relying on memory. Another benefit of this would be that these athletes could receive the help and treatment that they need sooner than if they were to wait until after their career is over, which could in turn possibly lessen the severity of their symptoms (if they have any).

The response was far less than was hoped and part of that can be attributed to the fact that the study asked participants to reflect on their behavior and their mental health. There is still a stigma around mental health and people who struggle with mental health disorders, especially within the world of athletics. According to the American Psychiatric

Association (APA), more than 50 percent of people with mental illness do not receive treatment for their disorder(s) (2020). These people often delay seeking help due to fears of being treated differently or losing their jobs; in the case of athletics, it could be fears of being treated differently by the team and coaches or fear of losing playing time or their spot on the roster. There are three types of stigma as described by the American Psychiatric Association: public stigma, self-stigma, and institutional stigma. Public stigma is the negative view that people hold regarding mental health and mental illness. These attitudes can be seen within the athletic community when a coach tells a player to “toughen up” or not to be upset. Self-stigma is the negative feeling and shamefulness that one with a mental illness feels about themselves. The shamefulness that a student-athlete felt as they read the survey questions asking them to rate their depression, anxiety and irritability could have led them to answer dishonestly or not at all, impacting the response rate to the survey. Institutional stigma is defined as systemic policies in government or private organizations that limit the opportunities of those with mental illness. An example of this could be that the NCAA did not require mental health care to be available to student-athletes at member schools until 2019. However, this guarantee is only for Division I student-athletes which means that student-athletes in Division II and III are still not being provided with adequate access to mental health services. While the NCAA is moving to improve mental health services available to their student-athletes, the recency of this policy only concurs that the stigma around mental health is still abundant within the athletic community. The implementation of this policy does not change the long-held attitudes of coaching staff and players on mental illness immediately which is

why athletes may have been hesitant to participate in a study that asks them to face their own stigmas and organization stigma.

This survey was conducted during the COVID-19 pandemic and that may have influenced some of the findings on mental health as well as response rate, which could be attributed to pandemic fatigue. All participants are college students whose world as students and athletes has been completely disrupted. Many students are doing what they can to just make it through the academic year. Screen time has increased dramatically as students participate in online classrooms, online group project meetings, online team meetings, as well as completing all their homework which is generally done on a computer. Aside from academics, many athletics seasons were cancelled, post-poned, or modified in some way in order to follow school, state, and conference protocols for the pandemic. All these factors could have led to student-athletes not wanting to or being able to fill out the survey.

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APPENDICES

APPENDIX A: IRB APPROVAL

Application Narrative:

1. Funding: N/A

2. Summary:

There is a lot of research done to understand the acute effects of concussions, both on athletes and on the general population. However, the research is lacking on post-concussion syndrome and the long term effects of concussions, especially on student-athletes who may deal with multiple concussions throughout their athletic career. One symptom of post-concussion syndrome is depression (1). It is important to understand how a concussion can affect a person's long term behavior so that they can receive effective treatment when dealing with something like depression (1). It has been believed that once a concussion heals after the acute stages, cerebral functioning will return to normal. However, it has been found that even after suffering only one concussion, a person displays subtle cerebral functional changes despite the acute injury having healed (2).

Hypothesis: Concussions cause long-term behavioral effects on college student athletes that include but are not limited to depression, reactivity, and frustration.

This research project will provide an in-depth analysis of how Division I student athletes' behavior is affected following a concussion or concussions, even after the acute injury is healed. This will be accomplished by surveying Division I student athletes in the America East Conference. The survey will ask the student athlete's sport, if they have had a concussion, how many concussions they have had, how they perceive their own behavior to be, how they perceive their cognitive function to be, etc. This project is important because the information that is available about this topic is lacking but it is necessary in order to deem the safety level of allowing a student athlete to return to play after suffering and healing from a concussion. It has been found that other factors are at play when healing from a concussion aside from the initial injury (3). It is important to take all of these factors into consideration in order to provide the best, individualized treatment plan (3). Right now the treatment plans for those with concussions is generalized and not specific to each patient. With more research regarding the effects of concussion, especially on behavior, treatment plans could be more individualized and perhaps provide better outcomes for patients with concussion (3).

Methods: An anonymous Qualtrics survey will be sent to college student athletes that play football, men and women's soccer, men and women's hockey, and men and women's lacrosse in the America East Conference, Hockey East Conference, and Colonial Athletic Association (Appendix A) along with a written consent form (Appendix B). This survey will ask for demographic information such as year in college, sport, etc. After these background questions are addressed the survey will delve into the concussion and behavior questions. The data collected from the surveys will then be categorized and percentages of each category will be taken to better understand patterns and trends that the data reveals.

One of the interesting aspects of this thesis is that it combines the athletic training discipline with psychology to better understand how concussions converge with behavior. The research and analysis conducted by this survey will demonstrate how concussions affect a person's behavior not only in the short term but in the long term as well. The significance of this research comes from the hopeful conclusion that concussions do have long-lasting effects on a

person and do have an impact on their behavior even after the acute injury is healed and the athlete is considered to be cleared to play.

2. Personnel:

- Hannah Belleville, Undergraduate student in the Department of Communication Sciences and Disorders, College of Natural Sciences, Forestry and Agriculture and Honors College, Principal Investigator, 0 years experience with Human Subjects Research
- Ryan Taylor, Head Athletic Trainer and Instructor for the Athletic Training Program, Faculty Sponsor, 16 years experience with Human Subjects Research

3. Participant recruitment:

The characteristics of the participant population are NCAA Division I student athletes between the ages of 18-25. Plan to send out 3,000 surveys and expect a 20% response rate. Sought after participants are ones that have suffered a concussion or concussions. The proposed number of participants was determined because we wanted to have a broad range across multiple sports, multiple genders, and collect as many participants with concussions as possible in order to get the most representative sample possible of this population. Emails will be sent out to athletic trainers within the proposed conferences asking them to forward the survey link to athletes who meet the criteria. The emails to the athletic trainers will explain what the goal of the study is and ask them to send the study out to their athletes that meet the criteria. Attached to this email will be a second script for the athletic trainers to send to the student athletes on my behalf explaining the study (Appendix C).

4. Informed consent (See Sections I.K. and I.L. of Policy): Participating in the survey indicates consent.

5. Confidentiality:

The survey will be anonymous. Data collection will be done online using Qualtrics and IP addresses will not be collected. Data will then be downloaded onto researcher's computer from the program. Data on Qualtrics will be deleted immediately after the data is downloaded onto researcher's computer after data collection is complete. Data will be kept and stored in a secure file on the researcher's computer and a hardcopy will be kept by the researcher as a backup. The data on the researcher's computer will be kept and stored indefinitely on the researcher's computer. The hard copy will be destroyed in May 2022. If the data is published in the thesis, identifying references will be removed so as to protect the participants' anonymity.

6. Risks to participants: This study has minimal risk; only inconvenience and time. Participants may skip questions they prefer not to answer.

7. **Benefits:** There are no direct benefits to the participants. The overall potential benefit of the research is to gain a better understanding as to whether Division I student athletes sustain long-lasting behavioral affects after having sustained a concussion or multiple concussions.

8. **Compensation:** There is no compensation.

APPENDIX B: PROMIS-29

Definition of a concussion: A concussion is a type of traumatic brain injury—or TBI—caused by a bump, blow, or jolt to the head or by a hit to the body that causes the head and brain to move rapidly back and forth. It is characterized by a variety of symptoms that may include headache, dizziness, loss of balance, blurred vision, “seeing stars”, fogginess, memory problems, poor concentration, nausea, sensitivity to light and/or noise, confusion, feeling down or throwing-up. Important to note: getting “knocked out” or being unconscious does NOT always occur with a concussion.

1. Have you ever had a concussion (diagnosed or undiagnosed) ?

- a. No
- b. Yes

a.

b.

2. How many concussions have you had total?

- a. 1
- b. 2
- c. 3
- d. 4
- e. 5
- f. >5

3. What sport(s) do you play?

PROMIS 29 - Fatigue

4. In the past 7 days...

	Not at all (1)	A little bit (2)	Somewhat (3)	Quite a bit (4)	Very much (5)
I felt fatigued (1)					
I have trouble <u>starting</u> things because I am tired (2)					
How run-down did you feel on average? (1)					
How fatigued were you on average? (2)					

PROMIS 29 – Sleep part 1

5. In the past 7 days...

	Very poor (1)	Poor (2)	Fair (3)	Good (4)	Very good (5)
My sleep quality was (1)					
My sleep was refreshing (1)					
I had a problem with my sleep (2)					
I had difficulty falling asleep (3)					

PROMIS 29 – Pain Interference

6. In the past 7 days...

	Not at all (1)	A little bit (2)	Somewhat (3)	Quite a bit (4)	Very much (5)
How much did pain interfere with your day to day activities? (1)					
How much did pain interfere with work around the home? (2)					

How much did pain interfere with your ability to participate in social activities? (3)					
How much did pain interfere with your household chores? (4)					

PROMIS 29 – Pain Intensity

7. In the past 7 days...

	0 (No pain) (1)	1 (2)	2 (3)	3 (4)	4 (5)	5 (6)	6 (7)	7 (8)	8 (9)	9 (10)	10 (Worst pain imaginable) (11)
How would you rate your pain on average? (1)											

PROMIS 29 – Physical Function

8. Please respond to each question or statement by marking one box per row.

	Without any difficulty (1)	With a little difficulty (2)	With some difficulty (3)	With much difficulty (4)	Unable to do (5)
Are you able to do chores such as vacuuming or yard work? (1)					
Are you able to go up and down stairs at a normal pace? (2)					

Are you able to go for a walk of at least 15 minutes? (3)					
Are you able to run errands and shop? (4)					

PROMIS 29 – Social Roles and Activities

9. Please respond to each question or statement by marking one box per row.

	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Always (5)
I have trouble doing all of my regular leisure activities with others (1)					
I have trouble doing all of the family activities I want to do (2)					
I have trouble doing all of my usual work (include work at home) (3)					
I have trouble doing all of the activities with friends that I want to do (4)					

PROMIS – Emotional Support

10. Please respond to each item by marking one box per row.

	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Always (5)
I have someone who will listen to me when I need to talk (1)					
I have someone to confide in or talk to about myself or my problems (2)					
I have someone who makes me feel appreciated (3)					

I have someone to talk with when I have a bad day (4)					
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PROMIS 29 - Anxiety

11. In the past 7 days...

	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Always (5)
I felt fearful (1)					
I found it hard to focus on anything other than my anxiety (2)					
My worries overwhelm me (3)					
I felt uneasy (4)					

PROMIS 29 - Depression

12. In the past 7 days...

	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Always (5)
I felt worthless (1)					
I felt helpless (2)					
I felt depressed (3)					
I felt hopeless (4)					

NeuroQOL – Emotional Behavioral Dyscontrol

13. In the past 7 days...

	Never (1)	Rarely (2)	Sometimes (3)	Often (4)	Always (5)
I had trouble controlling my temper (1)					
It was hard to control my behavior (2)					
I said or did things without thinking (3)					
I got impatient with other people (4)					
I was irritable around other people (5)					
I was bothered by little things (6)					
I became easily upset (7)					
I was in conflict with others (8)					

AUTHOR'S BIOGRAPHY

Hannah Belleville was born in Salem, Connecticut on May 30, 1999. She was raised in Salem and graduated from East Lyme High School in 2017. Majoring in communication sciences and disorders, Hannah has a minor in psychology. She is a player on the University of Maine women's soccer team. She has received the Flagship Match Scholarship all four years and is a three-time scholar athlete.

Upon graduation, Hannah plans to attend graduate school in the fall of 2021 to study speech language pathology with a focus in strokes and traumatic brain injuries.