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LONGITUDINAL EXAMINATION OF PERCEIVED STRESS AND DEPRESSION
SYMPTOMOLOGY IN DIVISION I STUDENT-ATHLETES

BY
BOBBY DAIGLE

A thesis submitted in partial fulfillment of the requirements for the

Master of Science

Major in Nutrition, Exercise, and Food Science

Specialization in Exercise Science

South Dakota State University

2016

A Longitudinal Examination of Perceived Stress and Depressive Symptomology in
Division I Student-Athletes

This thesis is approved as a creditable and independent investigation by a candidate for the Master of Science degree and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

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ABSTRACT

LONGITUDINAL EXAMINATION OF PERCEIVED STRESS AND DEPRESSION
SYMPTOMOLOGY IN DIVISION I STUDENT-ATHLETES

BOBBY DAIGLE

2016

CONTEXT: Concussions are all too prevalent in amongst athletes. Concussions make up almost 5 percent of all collegiate athletic injuries. Concussions have been linked with many long lasting effects including depression and increased stress or anxiety.

OBJECTIVE: To longitudinally examine post-concussion depression and stress levels in National Collegiate Athletic Association Division 1 athletes.

DESIGN: Descriptive longitudinal study.

SETTING: National Collegiate Athletic Association Division I collegiate athletics.

PARTICIPANTS: Concussed and uninjured Division I collegiate athletes, ages 18-22, competing in football, women's soccer, baseball, softball, and women's track.

INTERVENTION(S): Participants completed the CES-D at baseline, 1 week, 1 month, and 3 months post-concussion and the PSS-14 at baseline and 1 month and 3 months post-concussion.

MAIN OUTCOME MEASURE(S): Baseline levels of depressive symptoms and perceived stress and differences between participants with and without a history of concussive injury were assessed. Longitudinal changes in depression and perceived stress and the association between these constructs were measured as well.

RESULTS: There were no differences in baseline depressive and stress symptomology between those who had 1 or more previous concussions and those with no history of

physician-diagnosed concussions. Depressive symptoms rose significantly one week post-concussion baseline and controls. Depressive symptoms returned to baseline levels by one month. There were no differences in perceived stress at any point. There was also no association between participants perceived stress and depressive symptoms.

CONCLUSIONS: Concussive injuries can lead to elevated depressive symptoms in Division I athletes. Concussed athletes' mental health should be monitored following a concussion and referral to a specialist made if warranted. Assessment tools such as the CES-D and PSS-14 can be helpful in monitoring the wellbeing of the athlete.

KEY WORDS: depression, stress, anxiety, concussion, CES-D, PSS-14, student-athlete

CHAPTER 1

Introduction

Studies have revealed that anywhere from 4 to 21 of 1000 athletes, from adolescence through adulthood, sustain a concussion at some point during their athletic careers. The incidence of concussions is especially concerning considering the global number of sport participants. Nearly 170,000 athletes participate in NCAA Division I athletics alone.⁶⁹ Concussions make up 5 percent of all NCAA injuries meaning on average over 8,000 Division 1 athletes sustain a concussion each year.⁵⁹

Aside from the risk of concussion associated with high level sport participation, research has revealed an increasingly disturbing link between concussions and a variety of potentially negative repercussions including varying levels of emotional dysfunction.⁵¹ This includes elevated stress levels and depressive symptoms, both of which have been linked to the post-injury recovery process in minor and major injuries including concussions.⁶⁰ In former NFL players who reported sustaining 1 or more concussions during their playing careers, nearly 27 percent reported having depressive episodes later in life compared to the players who reported never having a concussion during their career. In addition, while athletes from all levels have reported similar rates of depression as the general population, up to 15 percent who have sustained a concussion are shown to have an increase in depressive symptomology. Additional research in collegiate athletes has indicated that post-concussion depressive symptoms increase significantly over pre-injury values and can exceed a high risk threshold, necessitating a mental health referral.²² Research has also indicated that mTBI patients across a spectrum of ages report elevated levels of post-injury stress and anxiety that differs

significantly from otherwise healthy patients or patients with non-mTBI injuries.^{61,62} Furthermore, psychological distress following injuries is also increasingly recognized by healthcare providers including athletic trainers who have reported stress and anxiety as a primary response to athletic-related injuries.⁶⁵ Finally, while various researchers have isolated the effect of a concussion to either elevated stress or depressive symptoms, additional research has revealed a significant pre- and post-morbid association between anxiety, stress, and depression in adolescent patients through adults. Extensive previous life stressors have shown to develop depressive symptoms at a rate of 2.2 out of 100.⁶³ Also depression at baseline has been shown to be the strongest predictor of depression and anxiety following a concussions.⁵⁹ The occurrence of or association between post-concussion stress and depression should be alarming to patients and healthcare providers alike as both constructs have been linked to a variety of negative consequences including persistent post-concussion symptoms,^{6,16,32} decreased quality of life and life satisfaction, and suicide.^{11,13,41}

Despite the growing body of work related to post-concussion emotional dysfunction, several challenges remain. The available research that specifically analyzes collegiate athletes in a longitudinal fashion is fairly limited and often does not take into consideration fluctuations in emotional function over the course of a competitive sport season. Furthermore, varied study methodologies and injury definitions seen in the current literature often confound the understanding of the true nature of post-concussion emotional dysfunction. Therefore, the first purpose of this study is to determine how concussion history influences baseline levels of stress and depressive symptoms in NCAA Division I student-athletes. The second purpose of this study is to longitudinally

investigate the extent of and changes in post-concussion depressive symptoms and perceived stress in Division I student-athletes as compared to sport-matched healthy controls. The third purpose of this study is to determine the post-concussion association between depressive symptoms and perceived stress in NCAA Division I student-athletes.

Research Questions

This longitudinal examination of perceived stress and depressive symptoms is based on the following primary questions:

1. How does concussion history influence baseline levels of stress and depression in Division I student-athletes?
2. How do post-concussion stress and depressive symptoms in Division I student-athletes change over time compared to sport-matched healthy controls?
3. What is the post-concussion association between stress and depressive symptoms in Division I student-athletes?

Significance of the Study

Student athletes are already under added stress in comparison to the general population. With concussions adding to stress and causing depressive symptoms, student-athletes can become withdrawn and their performance in both the classroom and on the field may suffer.^{2,22} This study will provide a better understanding of perceived stress and depressive symptoms in student-athletes after sustaining a concussion. This study may also be used by clinicians to address these concerns to possibly help the student-athlete return to a more normal state after concussion symptoms have faded.

Definition of Terms:

1. Concussion: a traumatically induced transient disturbance of brain function that involves a complex pathophysiological process¹
2. mTBI (mild traumatic brain injury): Transient confusion, disorientation, or impaired consciousness; dysfunction of memory around the time of injury and LOC lasting less than 30 minutes²
3. Second-Impact Syndrome (SIS): repeat head injury before the symptoms of a previous head injury have resolved⁸
4. Post-Concussion Syndrome (PCS): a condition characterized by significant concussion symptoms that present days after the initial injury and persist for significant periods of time up to multiple months or even years.⁶
5. Depression: characterized by depressed mood, apathy, decreased sleep, fatigue, feeling of worthlessness, decreased concentration, and/or suicidal thoughts, has been linked to a wide range of diseases and injuries^{11,12}
6. Stress: an experience when people perceive situational demands to exceed their coping resources^{66,67}

CHAPTER 2

Review of Literature

The Review of Literature will examine the relationship between concussions, depression, and perceived stress or anxiety. This chapter will be divided into 5 primary sections: 1) Prevalence and Incidence of Concussions, 2) Depression and the Post-Injury Response, 3) Stress and the Post-Injury Response, 4) Association Between Stress and Depression, and 5) Human Impact of Stress and Depression.

Prevalence and Incidence of Concussions

According to the international conference on concussion a concussion is defined as “a traumatically induced transient disturbance of brain function that involves a complex pathophysiological process.”¹ Concussions are caused by an impulsive force transmitted to the head. Concussions most often result in the rapid onset of neurological impairment, but such impairments can be seen minutes or even hours after the incident. Concussions also present more as a functional impairment rather than a structural injury meaning no abnormalities are seen in neuroimaging studies. Concussions present with many different clinical symptoms. Concussions have often been described as mild traumatic brain injuries (mTBI); although many of the symptoms are similar, a mTBI is defined by having a loss of consciousness (LOC)² whereas LOC is not required for someone to be diagnosed with a concussion.

In the past decade emergency room visits for sport and physical activity related concussions have risen steadily and now approach 3.8 million annually.³ Researchers have reported that concussions occur at a rate of 4.3 per every 100 injuries⁴. In a study

focused on NCAA collegiate athletes, Hootman et al⁵ found that from 1988 to 2005, there was an annual rate of 3,753 concussions; football accounted for approximately 55% of these concussions.⁵

Concussion-related impairments and functional limitations including but not limited to headaches, nausea, memory loss, and sleep disturbances have been shown to greatly affect patients' abilities to perform in school and social settings, and engage in activities of daily life.⁶ While concussion recovery times vary, the vast majority of patients recover in under 2 weeks.⁷ However, concussive injuries can pose a threat for significant health consequences. Some patients may experience Post-Concussion Syndrome, a condition characterized by significant concussion symptoms that present days after the initial injury and persist for months or years.⁶ Furthermore, if an athlete returns to athletic participation before symptoms from a previous concussion have fully resolved, the athlete runs the risk of Second-Impact Syndrome (SIS). Defined as a "repeat injury before the symptoms of the previous head injury have resolved", SIS can be fatal.⁸ From 1980-2009, 17 high school athletes who sustained concussions and returned to play while still experiencing concussion-related symptoms, died on the field.⁹ While awareness of common signs and symptoms and the role of PCS and SIS has increased, researchers and clinicians are also increasingly recognizing and appreciating the emotional and psychological toll that concussions take on affected patients.

Depression and the Post-Injury Response

In 2010 the Centers for Disease Control (CDC) found that roughly 9% of citizens in the United States of America met the criteria for depression. Compton et al reported the prevalence of depression in the general adult population rose from 3.33% in 1991 to

7.06% in 2001.¹⁰ In a study of college athletes, Weingand et al¹¹ found that 17% reported high levels of depression.¹¹ Depression, characterized by depressed mood, apathy, decreased sleep, fatigue, feeling of worthlessness, decreased concentration, and/or suicidal thoughts, has been linked to a wide range of diseases and injuries. Oquendo et al¹² found that nearly 4% of patients with depression end up committing suicide.¹²

Traumatic brain injuries represent one of the leading causes of death and disability globally.¹³ In Scharchar et al's¹³ study of the incidence of TBI in Ontario, Canada, males between the ages of 16-24 incurred TBIs at a rate of 375 per 100,000 while females sustained 175 per 100,000. Particularly disturbing is the link to depression; DiBattista et al¹⁴ found that 18.2% of adolescents who had sustained a TBI reported clinical depression up to a year following the injury.¹⁴ Furthermore, 36.4% of the patients who sustained a TBI reported having a poor health related quality of life (HRQoL).¹⁴ Depression is not only present in adolescents following a TBI. An epidemiological study performed by Jorge et al found that 53.1% of adult patients who sustained a TBI reported depression up to a year following the injury. It was also found that 30 years post-injury, 26.7% of patients reported ongoing problems with depression.¹⁵

Researchers are now also beginning to gain a clearer picture of the relationship between concussions and depression. Multiple researchers have reported that compared to healthy individuals, adult patients who sustain concussive injuries experience elevated post-concussion depressive symptoms.^{16,17} Chrisman et al's¹⁸ findings revealed that adolescents were at a 3.3-fold greater risk for depression after sustaining a concussion compared to those who had never sustained a concussion.. Moreover, these adolescents were at a 3.8-fold greater risk of developing depressive symptoms while living in a house

with a parent that had poor mental health.¹⁸ Konrad et al¹⁹ found an increase in depressive symptoms in individuals who had previously sustained a concussion in comparison to individuals who had not while Dean et al⁶ reported that upwards of 31% of patients that had sustained a concussion reported elevated depressive symptoms. In other research, Kontos and associates²⁰ found that collegiate athletes reported an increase in depression 14 days after sustaining a concussion in comparison to control groups and high school athletes. Interestingly, several researchers have reported that depressive symptoms three months after sustaining a concussion were similar to a control group.^{6,32} A study of NCAA Division I athletes found that depressive symptoms were significantly higher at one week post-concussion compared to baseline but returned to baseline levels by 3 months post-concussion.²²

Studies of former professional athletes reveal similar findings relative to the prevalence of post-concussion depression but differences relative to long-term depressive symptoms. Results from Didehbani et al²³ and Strain et al²⁴ revealed that National Football League (NFL) players with multiple reported concussions throughout their playing career reported more symptoms on all three aspects of the Buckley Depression Scale in comparison to controls. In contrast to findings from other researchers,^{6,32} elevated depressive symptoms appear to be a long-term post-concussion concern in some professional athletes. Both Caron et al²⁵ and Edmed et al¹⁶ found that National Hockey League (NHL) players and NFL players who sustained multiple concussions during their playing careers remained affected by depressive symptoms years after their respective careers had ended. Hart et al²⁶ also found that 8 of 34 former NFL players who reported sustaining concussions throughout their career had battled with depression numerous

years after retirement, while Kerr et al's²⁷ results revealed that multiple concussions through a career increased the chances of having lasting depression. Specifically, Kerr and colleagues found a linear trend indicating that 3% of former NFL players who reported never sustaining a concussion were diagnosed with depression whereas 26.8% of former NFL players who had sustained 10 or more concussions were diagnosed with depression.²⁷

Stress and the Post-Injury Response

Stress has been defined as an experience where people perceive situational demands to exceed their coping resources.^{66,67} Stress is associated with increased heart rate, increased blood pressure, and a decrease of the immune system, and has also been linked to a variety of illnesses and injuries across a spectrum of patients. Kulsoom et al²⁸ found that 41% of medical students reported having an increased level of stress during examination times.²⁸ Stress also can impact individuals with varying illnesses and injuries. Brox et al²⁹ found that of patients with scoliosis, 31% showed a decrease in HRQoL with 7% of those patients citing anxiety as the primary reason.²⁹ Additional research on HRQoL in patients with benign breast lumps indicated that 40.2% of participants reported anxiety.⁵⁸ Another study on return to play anxiety following an injury revealed that 22 of the 36 NCAA division 1 athlete participants said they feel anxious when imagining returning to competition.³⁰

Similar to depression, increased stress and anxiety have also been linked to TBIs. DiBattista et al's¹⁴ study on adolescents affected by TBI found that 27.2% of the patients reported anxiety a year following the injury. In a study on physical and psychological responses following a TBI, Andruszkow³² and associates found that 3% of children and

8% of adults were diagnosed with anxiety according to the Hospital Anxiety and Depression Scale 10 years after sustaining the injury.³² In similar research, 13% of TBI patients were diagnosed with Post-Traumatic Stress Disorder (PTSD) as compared to 7.8% of the general population that had not sustained a head injury.¹³

Although not as common in athletics as in the military, PTSD is one of the most severe stress disorders that has been linked to concussions. Ponsford et al²³ found that in a general trauma ward, 123 patients that had sustained a concussion showed more signs of PTSD than a control group.³³ Furthermore, PTSD was reported in patients more commonly than post-concussive symptoms three months after sustaining the concussion. The researchers noted that PTSD was found to increase the patients' anxiety, resulting in feelings of unease in everyday life.³³

Concussions have also been shown to increase distress and perceived stress.^{7,34,35} In a study of 71 university students, Edmed et al¹⁶ found that 15% of participants that sustained a concussion reported an increase in post-concussion stress. Interestingly, post-concussion stress and anxiety can persist for varied lengths of time. Ponsford et al²³ investigated 123 mTBI emergency department patients and 100 control patients.³³ The authors completed one week and one month post-concussion checkups and found that 5% of patients reported increased anxiety three months following a concussion. In a study of 646 active duty marines, Spira et al³⁴ found that participants reported a 36% increase in perceived stress after sustaining a concussion and up to a 71% increase following multiple concussions that persisted up to six months.²⁶ Mainwaring et al³⁵ found that even if a concussed athlete does not report any perceived stress, stress symptoms may still be present. Despite being in an asymptomatic phase, post-concussion athletes

showed an increase in heart rate variability (HRV). Further, athletes that had sustained a concussion showed a greater perturbation in HRV during exercise in comparison to a control group that had not sustained a concussion.³⁵ Post-concussion HRV was also increased in the mornings compared to later in the day for the asymptomatic athletes who had previously sustained a concussion.

Association Between Depression and Stress

Findings linking both stress and depression to a wide range of situations, injuries, and disabilities have led researchers to explore the specific relationship between stress and depression. In a study of nursing professionals who had been performing their duties for at least one year, Gherardi-Donto et al³⁵ found that 34% of the 54 participants that reported high level of stress also had depression that was associated with the increased stress.³⁶ Another study on female nurses who worked in intensive care units saw the 86% had high levels of work stress and of those with stress had depression.³⁷

Weigner³⁸ and colleagues found that 59% of randomly selected women who ranged from 18-65 years of age with various marital statuses and job levels reported increased levels of work place stress; 33% of these women also reported an increase in depressive symptomology.³⁸ However, the authors were not able to determine if the increased stress levels caused the increase in depressive symptoms.³⁸ Similarly, Koreki³⁹ and colleagues found that 34.4% of workers in their study had significant depression levels that were positively correlated with the level of occupational stress.³⁹ Zannas et al's⁴⁰ longitudinal study of depression in geriatric patients revealed that perceived stress was linked to episodes of major depressive disorder and that changes in stress over time were associated with depression-related outcomes.⁴⁰ In other research, Suzuki et al found

adolescents reporting extensive previous life stressors, in particular those raised in foster homes or orphanages, developed depressive symptoms at a rate of almost 2.2 out of every 100.⁴¹

Research also reveals an important association between stress and depression in individuals who have sustained traumatic brain injuries. A study by Bay et al⁴² on 75 adult individuals from 18-65 who had sustained a traumatic brain injury diagnosed by a neuroscientist focused on the functionality of the patients along with chronic stress, depressive symptoms, cortisol levels, and fatigue. Results of this study showed that following a traumatic brain injury there was a significant negative correlation between chronic stress, activities of daily living, cognitive performance, and psychological disturbances.⁴² Depression was also negatively associated with psychological disturbances when all factors were combined. However, when chronic stress and depression were made independent of each other, chronic stress was still negatively correlated with the above symptoms whereas depression was no longer significantly associated.⁴²

Human Impact of Stress and Depression

The association between stress and depression appears quite clear. Furthermore, stress and depression remain prevalent across varied populations including college athletes.^{28,29,38} Regardless, stress and depression both individually and jointly can have a substantial negative influence on individuals who experience elevated symptoms of either construct. . Stress can lead to an increase in resting heart rate and sleep disturbances.³⁴ Moreover, increased heart rate and sleep disturbances can lead to a diminished quality of life.³⁴ A study on medical students showed that at the time of exams 77% of students had

poor sleep habits and 59.7% had high levels of stress. In a study of suicide rates related to major depression, Oquendo¹² and associates found that 60 % of suicides were associated with patients who had mood disorders.¹²

The influence of stress and depression is also evident in patients who have sustained a TBI. In a long term study of premature deaths following a TBI, Fazel et al⁴³ found that 522 of the 2408 premature deaths were the result of suicide.⁴³ Not all patients who sustain a TBI will necessarily be at risk for premature death, but the impact on QOL is still evident. A longitudinal study by Bay and Leon⁴² on 84 patients following an mTBI found that the patients who had increased perceived situational stress had a significantly decreased fatigue-related QOL, in particular mental fatigue.⁴² The perceived stress of these patients was believed to be chronic in nature as subjects were assessed on average 15 months post injury . A two year longitudinal study on sleep disturbances in children performed by Tham et al⁴⁴ found that children who had sustained an mTBI or TBI showed significant increases in sleep disturbances compared to the general population at 3 and 12 month follow up assessments.⁴⁴ The children who had sustained a TBI continued to experience significant sleep disturbances 24 months post-injury compared to the general population. In other work, Hammergen et al⁴⁵ completed a 10 month retroactive study focused on functional QOL in 62 patients who had been admitted to a Trauma Referral Center in Norway⁴⁵. All of the patients had been diagnosed with mild to severe TBI. Results showed that 19% of the patients had epilepsy and 31% had been diagnosed with depression. Additionally, only 45% of participants were currently employed compared to 81% prior to the injury.⁴⁵ In comparison to the

general population, participants also reported lower QoL relative to physical functioning, physical role, general health, vitality, social functioning, and mental health.⁴⁵

Conclusion

The rate of concussions occurring in athletics has risen in recent years with 4.3 out of every 100 injuries in athletics now classified as a concussion. In collegiate athletics, nearly 3,800 concussions occur on an annual basis. Concussions remain a cause for concern due to a variety of negative post-concussion responses including increased rates of depression and perceived stress. Studies have shown that upwards of 31 percent of patients report increased depressive symptoms following a concussion; collegiate athletes have reported increased depressive symptoms up to 14 days post-injury. Furthermore, stress has been shown to increase in concussed patients, with up to 15 percent of patients reporting increased post-concussion perceived stress. Depression and stress are not always exclusive from each other. Studies show that anywhere from 33-86 percent of patients with increased stress levels also have increased depressive symptoms. Unfortunately, depression and stress can substantially influence a person's life. Patients with increased situational stress have reported decreases in overall quality of life. In addition, approximately 60 percent of suicides are associated with mood disorders including depression. Research indicates that following a TBI, almost 22 percent of premature deaths were caused by suicide. Also, longitudinal studies have shown up to a 45% decrease in employment rate in individuals who have sustained a TBI. In light of these findings, more research needs to be done in order to better understand the influence and longitudinal effects of concussions on depressive symptoms and perceived stress in Division I athletes.

CHAPTER 3

Methodology

Participants

Participants in this study were male and female student-athletes who participated in either football, women's soccer, women's volleyball, baseball, women's track and field, or softball at an NCAA Division I university. All participants were between the ages of 18-22. Participants in this study included individuals who sustained a physician-diagnosed concussion during the course of their respective competitive season (n=12) as well as sport-matched healthy controls (n=24). Participants who had sustained a physician-diagnosed concussion in the previous 6 months or who indicated a prior history of diagnosed depression or other psychological disorder were excluded from the study.

Instrumentation

The Center for Epidemiologic Studies Depression Scale (CES-D) and the Perceived Stress Scale (PSS-14) were used to measure depressive symptoms and perceived stress. The CES-D is a self-report depression scale developed by Radloff et al.⁴⁵ The CES-D has been used with a range of participants including college athletes and has been shown to be a reliable depression screening tool for individuals who have sustained a TBI.^{45,46,47} The CES-D contains 20 statements based on feelings over the past week that are measured on a 4 point scale with scores of 0 representing never to 3 representing very often. Overall scores on the CES-D can range from 0-60. Individuals

scoring 16 or higher are at a higher risk of developing serious depression and should be further evaluated by a mental health professional.⁴¹

The Perceived Stress Scale (PSS-14) is a self-report scale used to measure an individual's level of perceived stress. The PSS-14 uses a 5 point scale based off of participants perceptions over the past month and includes questions such as “In the last month, how often have you felt nervous and “stressed”?” and “In the last month, how often have you been upset because of something that happened unexpectedly?” A score of 0 represents never and 4 represents very often with overall scores ranging from 0-56. The PSS-14 has been used to effectively measure college-age individuals' perceived level of stress at varying points following a traumatic event, including after an mTBI.^{50,51} The PSS-14 provides a more thorough understanding of an individual's overall appraisal of stress and has been shown to be more effective in predicting health outcomes than life-event scales.⁵⁰

Procedure

Data was collected over a period spanning the 2014-2016 sport seasons. Institutional Review Board approval was obtained prior to the collection of any data. Every student-athlete at this University completed baseline measures for depressive symptoms and perceived stress during their pre-season physical exams. At this time, all athletes who agreed to be a part of this study signed an informed consent letter.

Athletes were monitored during their competitive seasons by certified athletic trainers responsible for the healthcare needs of each of the specific sport teams. If an athlete sustained a concussion, the primary researcher was notified and met with the athlete within 24 hours to verify continued consent to participate in the study. The

primary researcher also contacted 2 sport-matched healthy controls for each concussed participant to verify their continued consent to participate in the study. The concussed participants, along with their 2 sport-matched healthy controls, then completed the CES-D at 1 week, 1 month, and 3 months post-concussion. Participants also completed the PSS-14 at 1 month and 3 months post-concussion. The assessment time points were chosen based on prior research related to the timing of post-concussion emotional disturbance as well as typical time periods during which concussed individuals experience the most rapid recovery.^{22,52,53}

All questionnaires and athlete information was kept in a single locked box to which only the primary researcher had access.

Data Analysis

Means and standard deviations were calculated to quantify levels of perceived stress and depressive symptoms. Further, frequency distributions of depressive symptoms that exceeded the at-risk threshold (≥ 16) and levels of low, moderate, and high stress were also calculated.

Parametric statistics were used in this analysis because the PSS-14 and CES-D scores represent the sum of a series of Likert scale questions. Outcome variables were tested for normal distributions prior to analysis and residuals from regression models also were tested for normality. Analysis of variance was used to determine if PSS-14 and CES-D were greater in individuals with a history of concussion and if the number of concussions a person had suffered was associated with an increase in these values. Linear mixed models were used to evaluate differences in longitudinal changes in post-concussion perceived stress and depressive symptoms between injured individuals and

healthy controls. Differences in perceived stress and depressive symptoms between the concussed participants and their sport-matched healthy controls at each time point were assessed via a group-by-time interaction. A Pearson correlation coefficient was calculated to examine the relationship between perceived stress and depressive symptoms. We analyzed all data using Stata Release 12 (StataCorp LP). Statistical significance for all analyses was set a priori at $\alpha=0.05$.

CHAPTER 4

Results

Descriptive statistics

The average age of the participants in this study was 20.8 ± 3 years. In the concussion group ($n=12$), 6 participants were in football, 2 in women's soccer, and 1 each in women's volleyball, baseball, women's softball, and women's track. Each of the concussed participants was sport-matched with 2 healthy controls ($n=24$). The average length of recovery from the onset of the concussion until physician clearance to return to play was 17.4 ± 60 (4-77) days.

Baseline Depressive Symptom and Perceived Stress Levels

Table 1 shows means and standard deviations for depressive symptoms and perceived stress in concussed participants and their sport-matched healthy controls at each assessment point. Baseline depressive symptom scores between previously concussed participants (8.86 ± 9) versus those with no history of concussion (8.14 ± 11) were not significantly different. The average baseline level of perceived stress across all participants was in the low to moderate range and was not significantly different between participants with a history of 1 or more physician-diagnosed concussions (19.6 ± 10) and

those with no history of concussive injury (20.3 ± 19). Neither perceived stress scores nor depressive symptom scores were associated with the number of physician-diagnosed concussions reported on participants' pre-participation medical history questionnaires.

Table 1. *Depressive Symptoms and Perceived Stress at Each Assessment Point*

	Baseline	1 Week	1 Month	3 Months
CESD Case	7.3 ± 4.5	$14.6 \pm 8.7^{a,b}$	7.8 ± 8.7	6.5 ± 4.6
CESD Control	9.2 ± 5.1	9.5 ± 8.3^b	9.7 ± 6.9	7.4 ± 5.6
PSS Case	20.4 ± 5.7	Not Measured	18.7 ± 8.2	16.1 ± 6.4
PSS Control	20.4 ± 7.8	Not Measured	20.8 ± 7.9	17.8 ± 7.2

^aIndicates the mean is different from baseline $p < 0.05$

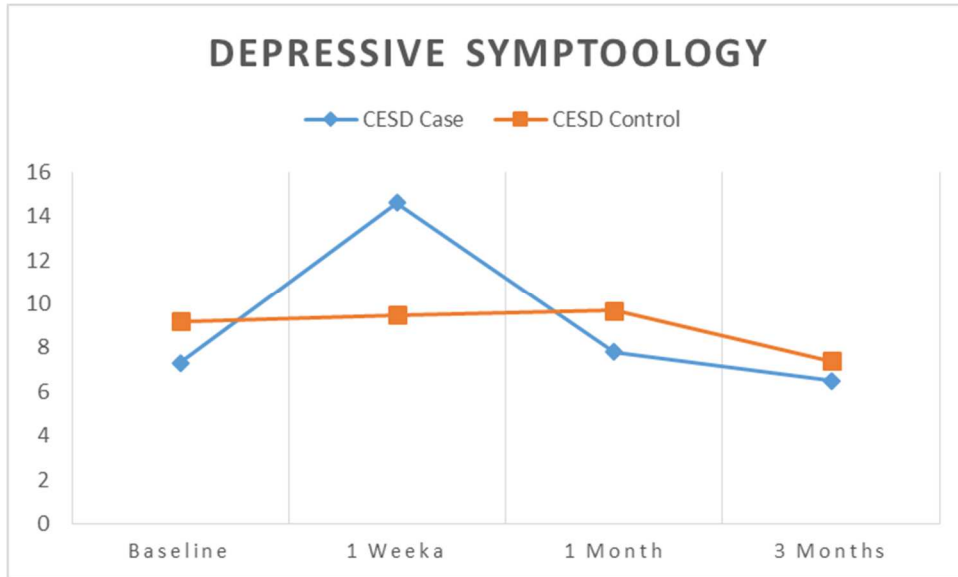
^bVariables with same letter are significantly different $p < 0.05$

Changes in and Association Between Depressive Symptoms and Perceived Stress

Concussed participants reported the highest overall depressive symptom scores one week post-injury with 6 of 12 participants (50%) scoring in a range considered at-risk for a clinical depression diagnosis. Depressive symptom scores in the concussed participants were significantly higher 1 week post-injury as compared to baseline ($+7.3$, $p = 0.001$, 95% CI = 2.8, 11.2)(Figure 1) while scores at 1 and 3 months post-concussion were not significantly different. The participants' scores returned to baseline numbers at 1 month (-6.8) and remained at baseline at the 3 month (-8.1) post-injury follow up. Compared to the sport-matched healthy controls, concussed participants' depressive symptom scores were significantly different 1 week post-injury but not at any other time point (Figure 1). There were no significant changes in perceived stress for concussed

participants or their sport-matched healthy controls at any of the assessment points. There was also no association between depressive symptoms and perceived stress.

Figure 1. *Longitudinal Changes in Depressive Symptom Scores*



^aIndicates the mean is different from baseline $p < 0.05$

CHAPTER 5

Discussion

Results from our research showed that all participants' baseline CES-D scores fell below the threshold for significant risk of clinically diagnosed depression (≥ 16).

Baseline perceived stress scores for all participants fell in the low to moderate range.

When comparing participants with no history of concussive injury and those reporting a history of 1 or more concussive injuries, two particularly interesting findings emerged.

First, there were no significant differences in baseline CES-D or PSS-14 scores between each of these groups. In addition, neither perceived stress nor depressive symptoms were associated with the total number of concussive injuries reported. These particular findings contradict previous research that suggests multiple concussions would increase long term depressive symptoms. Didehbani et al²³ found a significant correlation between the number of lifetime concussions and depressive symptomology in retired NFL players. One reason for our differing findings could be the number of concussions previously sustained. Our athlete with the highest number of previous concussions had 4 prior to injury, whereas Didehbani et al had players with more than 10 lifetime concussions.²³

Relative to longitudinal changes in depressive symptoms, the concussed groups' CES-D scores at the one week time point were significantly higher as compared to baseline values and the sport-matched healthy controls 1 week values. The finding of elevated depressive symptoms supports Vargas et al's work which found a reliable

increase in post-concussion depression among college athletes.⁶⁵ From the 1 week time point, depressive symptom scores significantly decreased, returning to baseline values by the 1 month time point. These findings are noteworthy on several fronts. The depressive symptomology scores may have increased at 1 week due to physiological damage to the brain.⁵⁴ Previous research suggests that concussions can cause physiological dysfunction in certain areas of the brain. In concussed NFL players, Strain et al²⁴ found a decrease in the relay functions of the frontal regions of the brain, where healthy participants had normal functioning frontal regions of the brain. The significant differences in 1 week depressive symptom scores found between the concussed participants and the sport-matched healthy controls also supports this point.

The elevated depressive symptom scores at 1 week could also have been linked to increased anxiety over participants' inability to participate in their sport. Both a loss of identity and anxiety have been associated with depressive symptoms.⁵⁵ However, this seems unlikely in our study as concussed participants' depressive symptom scores were already beginning to decline even though the average length of recovery before clearance to return to sport was nearly 18 days. This particular finding supports results from prior research on longitudinal changes in post-concussion depressive symptoms.²² The increased depressive scores found at 1 week may also have been linked to an increase in cortisol levels.^{42,55} Cortisol is a natural hormone that fluctuates in response to daily stresses. In patients who have sustained traumatic brain injuries, McEwen⁶³ found both hyper and hypo secreted levels of cortisol. Interestingly, both hypo and hyper secretion of cortisol have been reported in patients with major depression.⁶³

Concussed participants' decreases in depressive symptoms after the 1 week time point, similar to findings from prior work by Roiger et al,²² could also be explained by various factors. Primarily, the decrease in symptoms could simply be linked to the natural post-concussion recovery process. Bay et al⁴² found that depressive symptoms were more associated with increased daily disturbances caused by the physiological impairments of the concussion. Also patients in the Lange et al study who had their post-injury recovery complicated by depression showed an increase in post-concussion symptoms compared to patients who did not have lingering PCS. Similarly, our findings suggest that the decrease in depressive symptom scores could have resulted from progressive improvement in post-concussion physical symptoms. Along with cognitive and psychosocial resources such as rehabilitation clinics and therapy⁶⁶, social support has been shown to significantly help individuals following a traumatic life event, including brain injury. Specifically, satisfaction with available social support may explain the decreases in depressive symptoms revealed in the current study. Although Covassin et al⁵⁹ found that concussed collegiate athletes reported less satisfaction with overall social support as compared to athletes with orthopedic injuries, the researchers did find that both participant groups relied on similar sources of support. The decrease in depressive symptom scores from 1 week to 3 months in our study could indicate a satisfactory level of social support that assisted in participants' recovery. Finally, the decreases in depressive symptoms found after 1 week could be associated with the concussed participants' perceptions of their own quality of life. Di Battista and associate's¹⁴ findings revealed that self-reported depression was significantly correlated with self-reported HRQoL in nearly 88% of adolescent survivors of traumatic brain injury.

In regards to perceived stress, there were no differences between the participant groups at baseline, 1 month, or 3 months post-injury. This contrasts with Edmed et al¹⁶ who found that up to 15 percent of patients who sustained a concussion reported increased levels of post-concussion stress. Ponsford et al³³ also noted increased stress or anxiety up to three months post-injury in concussed patients. However, neither the Ponsford et al³³ nor Edmed et al¹⁶ studies used an athletic population. Our findings suggest that concussed participants did not perceive situations in their life, including the experience of the concussive injury, as stressful. These findings are supported by Bay et al⁴¹ who found that 12 hour post-injury cortisol levels were actually lower than average in patients that had sustained a traumatic brain injury. However, research indicates that chronic stress may negatively affect regular cortisol release.^{41,55,63} Participants in our study may have already been in a state of chronic stress at the time of enrollment in our study. Raglin et al's⁵⁶ results indicating that athletes experienced increased stress during their competitive seasons supports this possibility. Finally, the perceived stress findings in our study could also be explained by the availability of adequate social support. Covassin and colleagues⁵⁹ found that higher degrees of satisfaction with social support were associated with lower post-injury state anxiety levels. Participants in our study may have perceived both adequate sources of and satisfaction with social support mechanisms.

With no significant differences in perceived stress at the different time points and depressive symptom scores returning to baseline values by 1 month, there was no correlation between these constructs in our study. This is surprising when compared to findings from prior research which found that 33 percent of participating psychiatrists that had reported increased levels of perceived stress also had an increase in depressive

symptoms.³⁸ Our results compared to those of prior research could be linked to methodological considerations. Since the PSS-14 is based on perceptions over the past month, we did not measure perceived stress at the 1 week time point. This could have influenced our findings as Gherardi et al³⁶ also found a relationship between stress and depression that suggested athletes may be predisposed to increased stress.

Even though the average CES-D score for concussed participants at 1 week post-injury did not reach a level considered at-risk for clinical depression, 6 of the 12 participants reported scores that did exceed the at-risk threshold. Only 2 of these participants retained an at risk level of depressive symptoms at the 1 month time point. However, 1 additional participant who did not report an at-risk score at 1 week did so at 1 month. The fluctuation in at-risk scores could be explained by duration and severity of post-concussion physical symptoms or individual coping abilities. The participant who first reported an at-risk score at 1 month may not have realized the full significance of the concussion until later in the recovery process. Regardless, these findings need to be interpreted with caution because of the serious long term implications of concussions. The potential alteration of brain function following a concussion can be alarming,²⁴ with long term difficulties ranging from increased anxiety and depressive symptoms up to 30 years post-concussion^{26,45} and to suicide.^{42,43}

Limitations

This study focused on sport teams from a single NCAA Division I university, therefore, our findings may not be representative of all college student-athletes. Although the post-concussion assessments were conducted at the same time intervals, participants were evaluated at different points during their respective seasons which may

have affected the results. The study was limited by the number of concussions that occurred during the assessment period. However, the addition of sport-matched healthy control participants who completed all post-concussion assessments at the same time intervals as the concussed participants adds credence to the findings. Finally, neither the CES-D nor PSS-14 are diagnostic tools. The CES-D assesses extent of depressive symptoms and the PSS-14 assesses perceptions of stress as opposed to psychological symptomology. Therefore, results from this study should not be interpreted as participants being diagnosed with depression or any other psychological disorder.

Conclusions

Research has clearly shown that concussions can have a significant impact on the psychological well-being of the affected individual. This includes the possible development of post-concussion depression and an increase in perceived stress. Our study found that concussed individuals showed significant increases in depressive symptomology one week post-concussion that was different from the sport-matched controls and that returned to baseline by 1 month. We found no significant changes in perceived stress throughout the entire assessment period. In addition, there was no correlation found between perceived stress and depressive symptoms. In light of these findings and prior research on post-concussion depression, athletic trainers and healthcare providers should objectively evaluate concussed individuals' post-concussion depressive symptoms as a part of the injury management process. Furthermore, athletic trainers should have a documented referral plan to appropriate health care providers for concussed individuals who report at-risk depressive symptoms. Although our findings indicated no change in stress levels during the assessment period, prior research suggests

that athletic trainers may want to consider tracking student-athletes' perceived stress levels over the course of their competitive seasons. Doing so may help identify seasonal or other influences on stress levels or even enhance athletic performance.

Research has also illuminated the importance of social support in the post-injury recovery process, including concussions. Efforts to foster social support may include informing roommates how to help the concussed athlete, educating professors on the effects of concussions the need for cognitive rest, and working with counselors to help athletes cope with the recovery process.

Considering our findings and those from prior research related to elevated post-concussion depressive symptoms, several research recommendations are in order. Future research efforts should examine rates of depression and levels of stress in formerly concussed individuals in comparison to otherwise healthy controls. In addition, researchers should evaluate the long-term effects of post-concussion depression or stress, in particular on individuals' perceptions of their quality of life. Both of these recommendations are especially important in a largely understudied population such as former college student-athletes who have transitioned to life after competitive athletics. Future research should also focus on using a stress measuring tool that designed to measure stress over the past week instead of the past month. A tool like this would help with measuring any correlation between stress and depressive symptoms at the height of the found depressive symptomology at one week post-concussion. Future research should also investigate the perceptions of social support as moderators of depressive symptomology and perceived stress. Also more long term studies should be performed on

student athletes to see if and how a sustained concussion is affecting them in life after athletics.

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Appendix A
(Information Sheet - Consent)

Information Sheet

Participation in a Research Project

South Dakota State University

Brookings, SD 57007

Department of Health and Nutritional Sciences

Project Director: Bobby Daigle

Phone No. 605-651-2861

E-mail Bobby.Daigle@sdsstate.edu

Date: 10/8/2014

Please read (listen to) the following information:

1. This is an invitation for you as a student athlete to participate in a research project under the direction of Bobby Daigle, ATC, Graduate Student in Nutrition and Exercise Science, under the direction of Dr. Trevor Roiger.
2. The project is entitled "A Longitudinal Examination of Perceived Stress and Depressive Symptomology in Concussed Division I Student Athletes".
3. The first purpose of this study is to determine the extent to which NCAA Division I student-athletes demonstrate post-concussion depressive symptoms as measured by the Center for Epidemiological Studies – Depression Questionnaire. The second purpose of this project is to longitudinally investigate the extent of post-concussion depression and perceived stress in Division I student-athletes. The third purpose of this study is to determine differences in depressive symptoms and perceived stress between concussed NCAA Division I student-athletes and uninjured controls. The final purpose of this study is to determine the association between depressive symptoms and perceived stress.
4. If you consent to participate, you will be involved in the following process, which will take about 10 minutes of your time: At 1 week post-concussion, you will meet with the primary researcher at the PEC or Dykhouse athletic training room. At this meeting you will be asked to participate in the study, given informed consent, and fill out the CES-D questionnaire. Upon completion you will put the survey in one of two locked boxes (located in the PEC athletic training room & Dykhouse athletic training room) to which only the primary researcher has a key. This same procedure, along with the additional completion of the PSS-14, will be followed at one month and three months post-concussion.

5. Participation in this project is voluntary. You have the right to withdraw at any time without penalty and it will not affect your care at SDSU. If you have any questions, you may contact the project director at the number listed above.
6. There are no known risks in participation in this study.
7. There are no direct benefits for your participation in this study.
8. There is no compensation for your participation in this study. Also, there will be no reimbursement for travel or parking for participating in this study.
9. Your responses are strictly confidential. When the data and analysis are presented, you will not be linked to the data by your name, title or any other identifying item. To ensure optimal health of study participants, any participant who reports an “at-risk” depressive symptomology score at any assessment point will be directed to Head Athletic Trainer Owen Stanley to discuss the possibility of a referral for mental health counseling.
10. As a research participant, I have read the above and have had any questions answered. I will receive a copy of this information sheet to keep.

If you have any questions regarding this study you may contact the Project Director. If you have questions regarding your rights as a participant, you can contact the SDSU Research Compliance Coordinator at (605) 688-6975 or SDSU.IRB@sdstate.edu.

This project has been approved by the SDSU Institutional Review Board, Approval No.: IRB-1410012-EXP.

Appendix B

(Center for Epidemiologic Studies – Depression (CES-D))

CES-D QuestionnaireBaseline

Name: _____ Date of Injury: _____

Everyone—no matter how happy they are—experiences depressive symptoms from time to time. This survey measures how many of those depressive symptoms you felt during the past week. Consider each question and select the answer that best describes how you have felt **over the past week**. Please circle an answer for each question.

1. I was bothered by things that don't usually bother me.
 - Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)

2. I did not feel like eating; my appetite was poor.
 - Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)

3. I felt that I could not shake off the blues even with the help of my family or friends.
 - Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)

4. I felt that I was just as good as other people.
 - Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)

5. I had trouble keeping my mind on what I was doing.
 - Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)

6. I felt depressed.
 - Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)

7. I felt everything I did was an effort.
- Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)
8. I felt hopeful about the future.
- Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)
9. I thought my life had been a failure.
- Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)
10. I felt fearful.
- Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)
11. My sleep was restless.
- Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)
12. I was happy.
- Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)
13. I talked less than usual.
- Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)

14. I felt lonely.
- Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)
15. People were unfriendly.
- Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)
16. I enjoyed life.
- Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)
17. I had crying spells.
- Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)
18. I felt sad.
- Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)
19. I felt that people disliked me.
- Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)
20. I could not get “going”.
- Rarely or none of the time (<1 day)
 - Some or little of the time (1-2 days)
 - Occasionally or a moderate amount of the time (3-4 days)
 - Most or all of the time (5-7 days)

Appendix C
(Perceived Stress Scale – 14 (PSS-14))

PSS-14**Baseline**

Name: _____ Date of Injury: _____

INSTRUCTIONS:

The questions in this scale ask you about your feelings and thoughts during THE LAST MONTH. In each case, you will be asked to indicate your response by placing an "X" over the circle representing HOW OFTEN you felt or thought a certain way. Although some of the questions are similar, there are differences between them and you should treat each one as a separate question. The best approach is to answer fairly quickly. That is, don't try to count up the number of times you felt a particular way, but rather indicate the alternative that seems like a reasonable estimate.

1. In the last month, how often have you been upset because of something that happened unexpectedly?

Never____ Almost Never____ Sometimes____ Fairly Often____ Very
Often____

2. In the last month, how often have you felt that you were unable to control the important things in your life?

Never____ Almost Never____ Sometimes____ Fairly Often____ Very
Often____

3. In the last month, how often have you felt nervous and "stressed"?

Never____ Almost Never____ Sometimes____ Fairly Often____ Very
Often____

4. In the last month, how often have you dealt successfully with day to day problems and annoyances?

Never____ Almost Never____ Sometimes____ Fairly Often____ Very
Often____

5. In the last month, how often have you felt that you were effectively coping with important changes that were occurring in your life?

Never____ Almost Never____ Sometimes____ Fairly Often____ Very
Often____

6. In the last month, how often have you felt confident about your ability to handle your personal problems?

Never____ Almost Never____ Sometimes____ Fairly Often____ Very
Often____

7. In the last month, how often have you felt that things were going your way?

Never____ Almost Never____ Sometimes____ Fairly Often____ Very
Often____

8. In the last month, how often have you found that you could not cope with all the things that you had to do?

Never____ Almost Never____ Sometimes____ Fairly Often____ Very
Often____

9. In the last month, how often have you been able to control irritations in your life?

Never____ Almost Never____ Sometimes____ Fairly Often____ Very
Often____

10. In the last month, how often have you felt that you were on top of things?

Never____ Almost Never____ Sometimes____ Fairly Often____ Very
Often____

11. In the last month, how often have you been angered because of things that happened that were outside of your control?

Never____ Almost Never____ Sometimes____ Fairly Often____ Very
Often____

12. In the last month, how often have you found yourself thinking about things that you have to accomplish?

Never____ Almost Never____ Sometimes____ Fairly Often____ Very
Often____

13. In the last month, how often have you been able to control the way you spend your time?

Never____ Almost Never____ Sometimes____ Fairly Often____ Very
Often____

14. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

Never____ Almost Never____ Sometimes____ Fairly Often____ Very
Often____